SWAMP
Surface Water Ambient Monitoring Program

Clean Water Act Section 305b Report 2006

Water Quality Assessment of the Condition of California Coastal Waters and Wadeable Streams

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California Water Boards

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LIST OF ACRONYMS A

CDF	cumulative distribution function
CDFG	California Department of Fish and Game
CCAMP	Central Coast Ambient Monitoring Program
CCLEAN	Central Coast Long-Term Environmental Assessment Network
CMAP	California Monitoring and Assessment Program
CWA	*Clean Water Act*
EMAP	Environmental Monitoring and Assessment Program
EMAP-W	Environmental Monitoring and Assessment Program-Western Pilot
EPIC	environmental protection indicators for California
IBI	index of biotic integrity
NPS	nonpoint source
O/E	observed/expected index
RMP	Regional Monitoring Program
RWQCB	Regional Water Quality Control Board
SFEI	San Francisco Estuary Institute
SQO	sediment quality objectives
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
U.S. EPA	United States Environmental Protection Agency

PREFACE

The federal *Clean Water Act's* Section 305b requires each state to report on the quality condition of its waters. The California State Water Board submits its water quality condition assessment report biennially to the U.S. Environmental Protection Agency (U.S. EPA). The reports submitted by states serve as the basis for U.S. EPA's *National Water Quality Inventory Report* to Congress. The *Inventory Report* is the primary report for the public about the condition of the nation's waters. The report is also used to inform water quality management decisions, including the allocation of certain *Clean Water Act* funds among states. However, key reviews of national and state monitoring and assessment efforts suggest that the *National Water Quality Inventory Report* does not accurately portray water quality conditions, that the monitoring done by states does not always allow for valid assessments of water quality condition in unmonitored waters, and that a consistent approach to monitoring and data collection is needed to support core water programs (U.S. Government Accounting Office, 2000; National Research Council, 2001). As a result, the information provided on the status and trends of waters at statewide and at national scales may be inadequate to support decision making.

The water quality condition assessment reports submitted thus far by California have been based on a regional approach to reporting. The approach corresponds to the structure of the nine California Regional Water Boards and provides essential information for specific waterbodies. However, the assessments cannot be successfully integrated into an accurate statewide report because regions use a variety of assessment approaches and do not always apply criteria consistently. Also, due to limited resources, monitoring has generally focused on problem identification. Clean waters were less likely to be targeted for monitoring, and assessments were based on data with a bias towards sites that were likely sampled due to suspected problems. Furthermore, assessments could not be extrapolated to unmonitored waterbodies or those with insufficient data.

That there is no current way to develop a valid national picture of water quality condition speaks both to the monitoring and assessment challenges faced by states as well as the need for improved assessment tools. The California Water Boards have actively taken steps to meet these challenges. The Surface Water Ambient Monitoring Program's (SWAMP) comprehensive monitoring and assessment strategy describes some of these steps (A comprehensive monitoring and assessment strategy to protect and restore California's water quality. Surface Water Ambient Monitoring Program. 2005. [http://www.waterboards.ca.gov/swamp/reports.html]). As part of the strategy, SWAMP has partnered with U.S. EPA on large-scale monitoring efforts through the Environmental Monitoring and Assessment Program. The Environmental Monitoring and Assessment Program effort relies on a statistical monitoring approach that allows assessments of the condition of waters to be extrapolated to unmonitored areas.

For 2006, U.S. EPA has agreed that California can use a different format to submit and meet its *Clean Water Act* Section 305b reporting requirements. This report would include assessments based on an evaluation of California data collected under U.S. EPA's Environmental Monitoring and Assessment Program. The assessments apply to two waterbody types: (1) coastal bays and estuaries and (2) wadeable perennial streams. "Wadeable" streams are streams, creeks, and small rivers that are shallow enough to sample without boats. The assessments focus on one beneficial use (aquatic life use) and are based on a limited suite of key indicators. Specifically, the report had to include sections summarizing:

- Statewide assessments of coastal bays and estuaries based on California data collected as part of the Environmental Monitoring and Assessment Program for Coastal Waters.
- Statewide assessments of wadeable perennial streams based on aquatic invertebrate data collected in California as part of the Environmental Monitoring and Assessment Program for Inland Surface Waters.
- Assessments of northern and southern coastal California's wadeable perennial streams based on aquatic invertebrate data collected in these areas as part of the Environmental Monitoring and Assessment Program for Inland Surface Waters.

When available, assessments from large-scale regional monitoring efforts such as the Regional Monitoring Program for San Francisco Bay, the Central Coast Long-Term Environmental Assessment Network, the Southern California Bight Project, and the Surface Water Ambient Monitoring Program have been included. Specifically, more detailed assessments of the San Francisco Bay, the Central Coast, and the Southern California Bight areas are included as part of the coastal waters assessment. More detailed assessments of the Santa Clara River Watershed in Southern California and waters in the Central Coast region are included as part of the wadeable perennial streams assessment. Brief summaries of the Regional Water Boards' surface water ambient monitoring programs are included in the final section of this report.

EXECUTIVE SUMMARY ES

The federal *Clean Water Act* gives states the primary responsibility for protecting and restoring water quality. To meet *Clean Water Act* objectives, California must answer these key questions:

- What is the overall quality of California's surface waters?
- To what extent is surface water quality changing over time?
- What are the problem areas and areas needing protection?
- What level of protection is needed?
- How effective are clean water projects and programs?

Adequate and accurate monitoring and assessment are the cornerstones to preserving and restoring water quality. The information gathered from monitoring activities is critical to protect the beneficial uses of water, develop water quality standards, determine effects of pollution and of pollution prevention programs, and conduct federal *Clean Water Act* assessments.

One of the first steps in managing our environmental resources is to determine their current condition by answering the key question, "What is the overall condition of California's surface waters?" Often-raised questions relating to the condition of our waters include, "Is the water safe to drink?" "Are the waters safe to swim?" "Are the fish safe to eat?" "Is aquatic life healthy?" The condition assessments presented in this report focus on two waterbody types: coastal bays and estuaries and wadeable perennial streams. The assessments in this report focus on the question "Is aquatic life healthy?" The "aquatic life" use designation in California's water quality control plans refers to the beneficial uses of waters that support either warm-water or cold-water ecosystems, including fish, wildlife, invertebrates, vegetation, and other components of aquatic ecosystems. While historical assessments of water quality have primarily focused on describing chemical water quality, this report includes assessments based on biological indicators when available.

This report includes assessments of the condition of coastal bays and estuaries and wadeable perennial streams statewide based on data collected through the Environmental Monitoring and Assessment Program led by the U.S. Environmental Protection Agency (U.S. EPA). These statewide assessments represent the state's initial attempt to make broad statistical estimates of the conditions of these waterbody types. It establishes baselines against which to compare future assessments. All the statewide assessments based on Environmental Monitoring and Assessment Program datasets have known levels of certainty. These confidence intervals are not included in this report but are available in the technical reports cited. The statewide assessments rely on data from a survey design that generates statistically defensible, unbiased assessments of the conditions of these waterbody types. As such, they did not specifically focus on areas of high impact. Other sampling, which has targeted such areas have shown toxicity and elevated chemical levels in some areas. In addition, only a limited set of indicators were used for the assessments. These indicators are specified in each section.

The report is organized into four main sections. The first section, Chapter 1, provides a brief introduction to aquatic life uses and condition assessments and a summary of the datasets used in the report. Chapter 2 presents statewide and regional condition assessments for California's coastal bays and estuaries. Chapter 3 summarizes statewide, regional, and local watershed condition assessments for California's wadeable streams. All statewide assessments are based only on data from the Environmental Monitoring and Assessment Program. The final section, Chapter 4, includes brief summaries of the Regional Water Boards' surface water monitoring programs.

CALIFORNIA'S COASTAL BAYS AND ESTUARIES

California's coastal waters, which include estuaries, bays, harbors, and coastal shoreline, provide an important link between land and sea and between freshwater and saline environments. These waters provide unique and critical habitats for fish, birds, and other wildlife. Coastal waters also support commercial and recreational activities that are vital to California's economy.

What is the overall condition of coastal bays and estuaries in California?

Assessments based on U.S. EPA's Environmental Monitoring and Assessment Program for Coastal Waters (EMAP-Coastal Waters) data collected in California from 1999 through 2000 suggest that most of the state's coastal waters appear to be in "fair" to "good" condition based on the water and sediment quality indicators used (Summary Table i). A limited suite of key water and sediment quality indicators were used. The water quality indicators used were dissolved oxygen, nutrients (nitrogen and phosphorus), chlorophyll *a*, and water clarity. The sediment quality indicators used were total organic carbon, sediment chemical contamination, toxicity, and benthic faunal species richness. The few high nitrogen levels were observed at Alviso Slough (South San Francisco Bay) and in samples collected at the mouths of the Pajaro River (Central California) and Santa Ynez River (Central California). The higher phosphorus values were observed in much of San Francisco Bay and in a few coastal estuaries (Santa Ynez River, Los Angeles Harbor, Santa Margarita River, and San Diego Bay). Although no sediments from San Francisco Bay were found to be toxic to the test organism *Ampelisca*, sediment toxicity tests using other test organism species indicated that some sediments from San Francisco Bay were toxic. Other test species, such as *Eohaustorius estaurius*, may be more representative test species for California. One of the sediment quality indicators, sediment chemical contamination, suggests poor conditions at less than 10 percent of the state. These areas tended to be in Southern California ports. It should be noted that this estimate may change based on the results of a more comprehensive evaluation of statewide sediment quality condition that is being done as part of the development of sediment quality objectives in California.

Summary Table i. Statewide assessment of coastal bays and estuaries.*

Condition Category	Water Quality Indicators				
	Dissolved Oxygen	Nitrogen	Phosphorus	Chlorophyll *a*	Water Clarity
% Area in High Quality	98	87	52	87	65
% Area in Moderate Quality	2	12	46	13	11
% Area in Low Quality	0	1	2	0	24
Condition Category	**Sediment Quality Indicators**				
	Total Organic Carbon	**Sediment Contamination**	**Amphipod Toxicity**	**Species Richness**	
% Area in High Quality	96	36	>99	78	
% Area in Moderate Quality	3	57	-	15	
% Area in Low Quality	1	7	<1	7	

* Results are based on data collected as part of the EMAP-Coastal Waters program. Sites were selected using a statistical sampling design in which every element of the population has a known probability of being selected. The sites were intended to be representative of all estuarine waters of the state.

Sites sampled in California for the EMAP-Coastal Waters program from 1999-2000. Sites were selected using a statistical sampling design in which every element of the population has a known probability of being selected. The sites were intended to be representative of all estuarine waters of the state.

What data were used for the statewide assessment of coastal bays and estuaries?

In 1999 through 2000, more than 130 sites including small estuaries, river-dominated estuaries in northern California, and San Francisco Bay were sampled in California as part of the EMAP-Coastal Waters program (see map). Sampling sites were intended to be representative of all estuarine waters of the state and were selected using a statistical sampling design in which every element of the population has a known probability of being selected.[1] Standardized field methods and laboratory protocols were used to ensure comparability.

1. For more information on probability-based surveys, see Box 1 and [http://www.epa.gov/nheerl/arm/designpages/monitdesign/survey_overview.htm].

What assessment thresholds were used to evaluate the data?

The threshold values used are the same ones used for the national coastal condition assessment (*National Coastal Condition Report II*. U.S. EPA, 2004. [http://www.epa.gov/owow/oceans/nccr/2005/downloads.html]. These thresholds were intended for comparison among states and do not necessarily reflect water quality standards for California. However, we use them here because specific thresholds have not yet been established for these indicators in California. The specific thresholds are shown in Summary Table ii.

Summary Table ii. Water and sediment quality indicator threshold values.

Condition Category	Water Quality Indicators				
	Dissolved Oxygen	Nitrogen	Phosphorus	Chlorophyll *a*	Water Clarity (% light penetration to 1m)
High Quality	> 5 mg/l	< 0.5 mg/l	< 0.01 mg/l	< 5.0 µg l	>20%
Moderate Quality	2-5 mg/l	0.5-1.0 mg/l	0.01-0.1 mg/l	5.0-20 µg/l	10-20%
Low Quality	< 2 mg/l	> 1.0 mg/l	> 0.1 mg/l	> 20 µg/l	<10%

Condition Category	Sediment Quality Indicators			
	Total Organic Carbon	Sediment Contamination	Amphipod Toxicity	Species Richness (% expected species richness normalized for salinity)
High Quality	< 2 %	<5 contaminants exceed Effects Range Low	>80% survival	> 90%
Moderate Quality	2 – 5 %	5 or more contaminants exceed Effects Range Low (none exceed Effects Range Median)	-	75 – 90%
Low Quality	> 5 %	1 or more contaminants exceed Effects Range Median	<80% survival	< 75%

How do the California results compare to national and major regional assessments of this waterbody type?

The results for California are comparable to West Coastal and national results reported in the *National Coastal Condition Report* (U.S. EPA, 2004). The West Coastal study area extends from the Washington-Canada border to the Mexican border. The national assessment applies to 28 coastal states and Puerto Rico. The California results are shown with the West Coastal and national results below. For ease of presentation, only the percent area in "low quality" condition are shown in Summary Table iii.

Summary Table iii. California coastal results compared with west coastal and national results.*

Indicator Type	Region		
	California (% area in Low Quality Condition)	West Coastal (% area in Low Quality Condition)	National (% area in Low Quality Condition)
Water Quality Indicators			
Dissolved Oxygen	0	1	4
Nitrogen	1	<1	5
Phosphorus	2	10	9
Chlorophyll *a*	0	<1	8
Water Clarity	24	36	25
Sediment Quality Indicators			
Total Organic Carbon	1	0	3
Sediment Contamination	7	3	7
Amphipod Toxicity	<1	17	6
Species Richness	7	13	17

* Results are based on data collected as part of the EMAP-Coastal Waters program. Sites were selected using a statistical sampling design in which every element of the population has a known probability of being selected. The sites were intended to be representative of all estuarine waters of the region.

What is the condition of coastal waters in specific coastal areas of California?

Findings from three large-scale monitoring programs focusing on the San Francisco Bay, the Central Coast, and the Southern California Bight are included. More detailed assessments for these areas are included in Chapter 2 and in technical reports (for links to reports, see Box 2).

- **San Francisco Bay:** Assessments based on the Regional Monitoring Program for the San Francisco Bay indicate that the two main contaminants of concern in the San Francisco Bay are mercury and PCBs. These contaminants were found at high enough concentrations to warrant a fish consumption advisory. Contaminated fish were found throughout the Bay; however, the highest concentrations of mercury and PCBs in the sediment and the water column were detected in the Lower South Bay. Toxicity has also been detected in both water and sediment samples collected from the Bay over the past 10 years.

- **Central Coast:** Assessments by the Central Coast Long-Term Environmental Assessment Network suggest a strong seasonal component to the loading of persistent organic pollutants, nutrients, and bacteria. The greatest loads of most persistent organic pollutants generally occurred during the wet season. Much higher loads of persistent organic pollutants were detected from rivers than from effluent discharges. The highest loads of nutrients and bacteria also occurred in the wet season, from December through March.
- **Southern California Bight:** The results of the Coastal Ecology component of the Southern California Bight Project are summarized in Chapter 2. The health of living resources based on biotic assemblages was generally found to be good. Benthic macrofauna were found to be healthy in more than 90 percent of the area. Demersal fish communities were found to be healthy in approximately 97 percent of the area. Although detectable levels of pollution were widespread, sediment contaminant concentrations were generally detected below levels expected to cause adverse biological impacts. Eighty percent of the Southern California Bight contained sediment for which there was minimal to no toxicity concern. The greatest prevalence and severity of toxicity were in port and marina areas within bays and harbors.

How will California continue to provide assessments of coastal waters statewide?

The state has joined with the U.S. EPA, the Southern California Coastal Waters Research Program, and Moss Landing Marine Laboratories in the EMAP-Coastal Waters Program. Bays and estuaries, intertidal wetlands, and offshore coastal waters have been or are slated to be monitored in 2002 through 2006. National Coastal Assessments will occur at five-year intervals and will be integrated with large-scale regional monitoring programs such as those for the San Francisco Bay, the Central Coast, and the Southern California Bight.

CALIFORNIA'S WADEABLE PERENNIAL STREAMS

Streams and rivers support aquatic life by providing habitat, spawning grounds, food, and shelter for fish, birds, and other wildlife. Approximately 34,000 miles of California's stream length are wadeable perennial streams. "Wadeable" streams are streams, creeks, and small rivers that are shallow enough to sample without boats. "Perennial" streams are those that contain water year-round.

What is the condition of wadeable perennial streams in California?

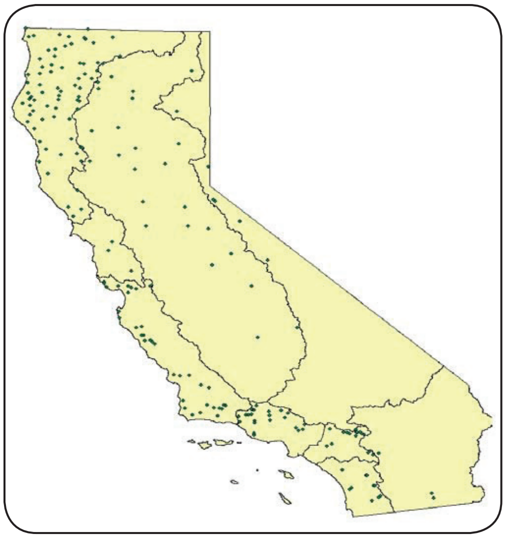
Assessments based on benthic macroinvertebrate data from the Environmental Monitoring and Assessment Program for Inland Surface Waters (EMAP-Inland Surface Waters) collected in California from 1999 through 2003, suggest 67-78 percent of wadeable perennial streams statewide are in "good" condition based on two benthic macroinvertebrate indicators (Summary Table iv). Benthic macroinvertebrates, which live on the bottom of streams, include aquatic stages of insects such as dragonflies and mayflies, crustaceans such as crayfish, and worms and snails. Since some benthic macroinvertebrates are more sensitive to pollution than others, we can determine a great deal about stream health from the organisms that live there. The two general types of benthic macroinvertebrate indices used for these assessments were the observed/expected index (O/E index) and the index of biotic integrity (IBI). The O/E index compares the number of taxa expected to exist at a site (E) to the number that are actually observed (O). The taxa expected at individual sites are based on models developed from data collected at reference sites. The IBI is the sum of a number of individual measures of biological condition, such as taxonomic richness and pollution tolerance. In both cases, the ability to recognize ecological degradation relies on understanding conditions expected in the absence of human disturbance.

There are well-established methods for assessing the biological condition of wadeable perennial streams based on benthic macroinvertebrate communities. An equally important subset of streams and rivers in California are non-perennial. This subset is not included in the assessment because suitable indicators are still currently being developed. Modified streams, which were not part of population of sites sampled by EMAP-Inland Surface Waters, are also not included in the assessment.

Summary Table iv. Statewide assessment of wadeable perennial streams.*

Indicator Type	% Stream Miles in Impaired Condition	% Stream Miles in Non-Impaired Condition
Statewide		
Western EMAP Macroinvertebrate Index of Biotic Integrity (W-EMAP IBI)	22	78
California Macroinvertebrate Observed/ Expected Index (California O/E Index)	33	67

* Results are based on benthic macroinvertebrate data collected as part of the EMAP-Inland Surface Waters program. Sites were selected using a statistical sampling design in which every element of the population has a known probability of being selected. The sites were intended to be representative of all wadeable streams of the state.



Sites sampled in California for the EMAP-Inland Surface Waters program from 1999-2003. Sites were selected using a statistical sampling design in which every element of the population has a known probability of being selected. The sites were intended to be representative of all wadeable streams of the state.

What data were used for the statewide assessment of wadeable perennial streams?

From 1999 through 2003, field crews sampled more than 190 randomly selected sites across the state and in three study areas in the northern, central, and southern coastal watersheds as part of the EMAP-Inland Surface Waters program (see map). Sites were chosen through a statistical sampling technique in which every stream segment has a known probability of being selected. Standardized field methods and laboratory protocols were used to ensure comparability.

What is the condition of wadeable perennial streams in the study areas?

The conditions of two large regions of California were also estimated using EMAP-Inland Surface Waters benthic macroinvertebrate data (Summary Table v). The northern coastal area of California produces 40 percent of the state's runoff and accounts for over half of private timber harvested in California. The southern coastal area (which includes both the central and southern coastal study areas) is an arid region that is undergoing rapid urbanization. More specific assessment details are summarized in Chapter 3 and in technical reports (see Box 2 for links to reports).

Summary Table v. Assessment of wadeable perennial streams in study areas.*

Indicator	% Non-Impaired	% Impaired
Northern Coastal		
Macroinvertebrate Index of Biotic Integrity (North Coast IBI)	94	6
Macroinvertebrate Observed/Expected Index (California O/E Index)	60	40
Southern Coastal (south and central coast combined)		
Macroinvertebrate Index of Biotic Integrity (South Coast IBI)	66	34
Macroinvertebrate Observed/Expected Index (California O/E Index)	67	33

* Results are based on benthic macroinvertebrate data collected in the study areas as part of the EMAP-Inland Surface Waters program. Sites were selected using a statistical sampling design in which every element of the population has a known probability of being selected. The sites were intended to be representative of all wadeable streams of the study areas.

- **Northern Coastal California:** Results for the northern coastal area suggest 60-90 percent of wadeable perennial streams in the area are in "good" condition. The macroinvertebrate index of biotic integrity developed for Northern Coastal California (North Coast IBI) suggests more than 90 percent of wadeable perennial streams in the area are generally in "good" condition. The California O/E index, however, indicates 60 percent of streams are in "good" condition. The wide range may suggest differences in sensitivities of the indices used or differences in how the thresholds were defined. The North Coast IBI is currently in the process of being refined to account for timber logging practices. The data will need to be reassessed in the future using the revised index.
- **Southern Coastal California:** Assessments based on benthic macroinvertebrate indices indicate that about 60 percent of the perennial wadeable stream length in southern coastal California are in "fair" to "good" condition based on the benthic assemblage. Both indices used produced nearly identical assessments of stream condition for this region.

What assessment thresholds were used to evaluate the data?

The assessments based on biotic indices use statistically established threshold values. These thresholds do not reflect water quality standards for California. However, we use them for assessment purposes because specific statewide thresholds have not been established in California for these indicators.

Summary Table vi. Assessment thresholds used for statewide and study area assessments.

Indicator	% Non-Impaired
Statewide	
Western EMAP Macroinvertebrate Index of Biotic Integrity (W-EMAP IBI)	IBI score of <57 for mountain sites; IBI score of <47 for xeric sites
California Macroinvertebrate Observed/Expected Index (California O/E Index)	O/E score of <0.77
Northern Coastal	
North Coast Macroinvertebrate Index of Biotic Integrity (North Coast IBI)	IBI score of <52
California Macroinvertebrate Observed/Expected Index (California O/E Index)	O/E score of <0.77
Southern Coastal (south and central coast combined)	
South Coast Macroinvertebrate Index of Biotic Integrity (South Coast IBI)	IBI score of <39
California Macroinvertebrate Observed/Expected Index (California O/E Index)	O/E score of <0.77

What are the results of national and major regional assessments of wadeable streams?

A recently released U.S. EPA draft assessment reports that some 53 percent of the nation's stream miles are in "fair" to "good" condition based on a national macroinvertebrate IBI. This national assessment applies to the lower 48 states. The draft report also includes assessments of three major regions of the United States: the Eastern Highlands, the Plains and Lowlands, and the West. Of these three regions, the West is in the best condition, with 71 percent of its length of wadeable waters in "fair" to "good" condition.

Based on thresholds developed for western streams (the Western-EMAP IBI results), the condition of California streams appears to be comparable to the condition of western streams and better than the condition of the nation's streams. However, this result should be interpreted with caution because of differences in thresholds used. Also, modified channels were not included in the monitoring design. Modified channels comprise a larger proportion of California stream length than they do in most other western states.

What is the condition of perennial wadeable streams in specific areas of California?

Assessments of local watershed conditions for waterbodies in the Central Coast region and for the Santa Clara River Watershed are included in Chapter 3 of this report. For the Santa Clara River watershed, 76 percent of the stream miles were found to be in "moderate" to "high quality" condition based on the Southern California benthic macroinvertebrate index. Aquatic life use assessments for specific waterbodies in the Central Coast Region are summarized in Chapter 3.

How will California continue to provide statewide assessments of wadeable streams?

Periodic statewide assessments of wadeable streams will be possible through the California Monitoring and Assessment Program (CMAP). CMAP is a collaboration with the U.S. EPA, the State Water Board's Nonpoint Source Program and Surface Water Ambient Monitoring Program, the California Coastal Commission, and the Department of Fish and Game. CMAP builds on the EMAP-Inland Surface Waters program and follows a similar sampling design except that it is stratified by land cover classes such as agriculture, urban, and forest. CMAP also includes modified channels. Approximately 50 sites per year are sampled as part of CMAP. The program will allow for biennial statewide condition assessments. It will also enable us to begin evaluating associations between observed biotic effects and nonpoint source land use categories.

BOX 1. MONITORING APPROACHES

The monitoring approach taken depends on the study objective(s) and a prioritization of resources. One monitoring design cannot answer all water resource questions, and different designs answer different sets of questions. The general strengths and limitations of different monitoring approaches (from Miller, 2005) are:

Targeted monitoring

- Sites are selected for monitoring based on a list of consideration and information needs.
- Results can help identify sources of water impairment, and determine if management actions are improving water quality.
- Information gathered is location-specific and cannot be extended to other areas except through mathematical modeling.

Probability-based or probabilistic monitoring

- Sites are randomly selected from all of the waters in a watershed.
- Results of monitoring are used to estimate water quality conditions in the larger area with known confidence.
- Cannot provide information on specific sites unless the sites were included in the random selection.

Characterizing populations

There are two generally accepted data collection schemes for studying the characteristics of a population. The first is a census, where every unit in the population of interest is surveyed. When a resource is extensive, as in most ecological studies, it is impractical and often impossible to conduct a census. For example, if we were interested in determining the fish assemblages within a large watershed or watersheds, a census would be prohibitively expensive to implement. An alternative approach for studying an extensive resource is to examine parts of it through probability sampling. A probability survey design relies on a statistical approach wherein only a subset of all waters are sampled, and the results from these are used to make estimates about the population with a known level of uncertainty [http://www.epa.gov/nheerl/arm/designpages/monitdesign/survey_overview.htm].

CHAPTER 1 INTRODUCTION

AQUATIC LIFE USES AND CONDITION ASSESSMENTS

This report provides information on the condition of coastal waters and wadeable streams relative to aquatic life use. Historical assessments of water quality have primarily focused on describing the chemical quality of our waters. In this report, we have added assessments based on biological indicators. Ultimately, estimates of condition should be based on fully integrated ecological assessments of multiple biological communities and assessments of physical and chemical condition.

The "aquatic life" designations in the state's water quality control plans refer to the beneficial uses of waters that support either warm-water or cold-water ecosystems, including fish, wildlife, invertebrates, vegetation (including algae), and other components of aquatic ecosystems. Aquatic life is an important attribute of the state's surface waters. Fish and crustaceans provide valuable recreation and economic benefits, and instream algae and macroinvertebrates provide the base of the food chain upon which fish, amphibians, birds, and other terrestrial animals rely.

Integrated assessments of the ecological condition of perennial streams rely on indicators such as biotic assemblages (for example, fish, benthic macroinvertebrates, periphyton) and the physical attributes of the stream channel and surrounding riparian area. The biotic assemblage and physical habitat parameters can reveal whether a stream is "healthy" or "degraded." In recent years, the Water Board's Surface Water Ambient Monitoring Program (SWAMP) has greatly advanced the scientific use of benthic macroinvertebrates as indicators of the health of aquatic life in perennial streams, but the development of assessment tools based on other indicators (such as periphyton, fish) has been very limited. Multiple indicators can provide insights into different components of biotic integrity. They can also shed light on the causes of any identified degradation. The long-term goal is to develop the tools needed for multi-indicator ecological condition assessments, as well as tools to identify the stressor(s) responsible for degradation that is identified by the assessments.

DATASETS USED

The condition assessments presented in the following chapters are based on data collected by various sources. These programs are described briefly within the report. Some of the information have previously been summarized in national and regional condition assessment reports, and in technical reports (see Box 2). The datasets used in this report include:

(a) **EMAP:** The statewide assessments for coastal bays and estuaries and for wadeable perennial streams are based on EMAP data. U.S. EPA initiated EMAP as a research program to develop the tools necessary to monitor and assess the status and trends of national ecological resources. The EMAP-Western Pilot was initiated in 1999 and included both a coastal and an inland surface waters component. A probabilistic monitoring approach was used to allow for extrapolation of condition to unmonitored waters (see Box 1 for more on design approaches). EMAP also promoted the development of indices for various biotic assemblages, such as benthic macroinvertebrates and aquatic vertebrates, that could be used for evaluating the condition of waters. All the statewide assessments based on EMAP data have known levels of certainty. Although these confidence intervals are not included in this report, they are available in the technical reports cited.

(b) **SWAMP:** The Water Board's SWAMP monitoring includes statewide and regional components.[2] Although the statewide component is not fully implemented, SWAMP is able to provide information on the status and trends in aquatic life for coastal waters and wadeable streams by partnering with other programs, such as EMAP. The statewide component for wadeable perennial streams builds upon the EMAP-Inland Surface Waters, and is implemented through collaborative efforts with various groups including U.S. EPA and the state's Nonpoint Source Program (NPS). Statewide assessments for coastal waters are possible through partnerships with EMAP-Coastal Waters. The regional component of SWAMP includes locally appropriate monitoring programs, each following consistent methods, quality assurance, and data management to ensure comparability of results. Chapter 4 summarizes these regional efforts.

(c) **Other Datasets:** The condition assessments based on data collected by other large-scale regional monitoring programs, specifically the Regional Monitoring Program for the San Francisco Bay, the Southern California Bight Monitoring, and the Central Coast Long-term Environmental Assessment Program, are also included.

2. The elements of SWAMP, current status, and priorities for implementation are presented in "A Comprehensive Monitoring and Assessment Strategy to Protect and Restore California's Water Quality," available at [http://www.waterboards.ca.gov/swamp/].

BOX 2. LINKS TO REPORTS

Coastal Condition

1. U.S. EPA Coastal Waters EMAP available at [http://www.epa.gov/owow/oceans/nccr/]:
    - *National Coastal Condition Report I* (2001)
    - *National Coastal Condition Report II* (2004)
2. San Francisco Bay Regional Monitoring Program available at [http://www.sfei.org/rmp/rmp_docs.html]:
    - RMP reports
3. Central Coast Long-term Environmental Assessment Network available at [http://www.cclean.org/ftp/Program_Documents.html]:
    - CCLEAN reports
4. Southern California Bight '98 available at [http://www.sccwrp.org/regional/98bight/98docs.html]:
    - 1998 Regional Survey Documents

Wadeable Streams Condition

1. U.S. EPA Inland Surface Waters EMAP available at [http://www.epa.gov/owow/streamsurvey/index.html]:
    - National Wadeable Streams Assessment draft
2. Surface Water Ambient Monitoring Program/NPS Program available at [http://www.waterboards.ca.gov/swamp/reports.html]:
    - CMAP technical reports for statewide, northern, and southern coastal California based on EMAP data
    - Assessment reports for local watersheds including the Santa Clara River watershed and Central Coast watersheds
3. Central Coast Ambient Monitoring Program available at [http://www.ccamp.org/ccamp/Reports.html]:
    - CCAMP reports

CHAPTER 2 COASTAL CONDITION

California's coastal waters, which include estuaries, bays, and harbors, provide an important interface between land and sea, and between fresh water and saline environments. Coastal waters provide unique and critical habitats, spawning grounds, food, and shelter for fish, birds, and other wildlife. Coastal estuaries such as San Francisco Bay, Tomales Bay, Humboldt/Arcata Bay, and numerous smaller estuaries provide critical habitat to support large numbers of migratory waterfowl and other birds. Estuaries and coastal beaches also support commercial and recreational activities that are vital to a region's economy.

The statewide coastal condition assessments are based on data collected in California as part of the EMAP-Coastal Waters. The aquatic life use indices used by EMAP to examine coastal condition are a combination of water and sediment quality indicators. This section also includes regional condition summaries from larger monitoring efforts in California for the San Francisco Bay, the Central Coast, and the Southern California Bight.

Figure 1. Sites sampled in California for the EMAP Coastal Waters program from 1999-2000. Sites were selected using a statistical sampling design in which every element of the population has a known probability of being selected. The sites were intended to be representative of all estuarine waters of the state.

A. STATEWIDE CONDITION

The EMAP-Coastal Waters Program in California focused on small estuaries when it was initiated in 1999. San Francisco Bay was sampled during the second year of the program. The survey used a probabilistic design to be representative of all estuarine waters of the State of California. Fifty probabilistic sites were sampled within the small estuaries of California. An additional 30 sites were distributed among the mouths of river-dominated estuaries in northern California, and about 50 sites were located in the San Francisco Bay. The sampling sites for 1999-2000 are shown in Figure 1.

The condition assessment presented in this section is based on water quality and sediment quality data collected from 1999 through 2000. The EMAP data have been summarized in various national coastal condition reports and technical reports (Nelson, Lee and Lamberson, 2003; U.S. EPA, 2001, 2004).

The same assessment threshold values used for the national coastal condition assessment were used for evaluating the California data

(Table 1; U.S. EPA, 2004). These thresholds were intended for comparison among states, and do not reflect water quality standards or thresholds of concern for California. However, we use these thresholds here since statewide thresholds have not been established for these indicators in California. The water quality indicators used are dissolved oxygen (DO), nutrients (nitrogen and phosphorus), chlorophyll *a*, and water clarity. The sediment quality indicators used are total organic carbon (TOC), sediment contamination, toxicity, and species richness. The percent area falling into each of the categories of condition for each indicator is summarized in Table 2. The cumulative distribution functions (see Box 3) for the 1999 data have been summarized in Nelson et al. (2005).

Table 1. Indicators and threshold values used in water quality assessment (from *National Coastal Condition Report II*, U.S. EPA, 2004).

Water Quality Indicators	Low Quality	Moderate Quality	High Quality
Dissolved Oxygen	< 2 mg/l	2-5 mg/l	> 5 mg/l
Nitrogen	> 1.0 mg/l	0.5-1.0 mg/l	< 0.5 mg/l
Phosphorus	> 0.1 mg/l	0.01-0.1 mg/l	< 0.01 mg/l
Chlorophyll *a*	> 20 µg/l	5.0-20 µg/l	< 5.0 µg l
Water Clarity (% light penetration to 1 m)	<10%	10-20%	>20%
Sediment Quality Indicators	**Low Quality**	**Moderate Quality**	**High Quality**
Total Organic Carbon	> 5 %	2 – 5 %	< 2 %
Sediment Contamination	1 or more contaminants exceed Effects Range Median	5 or more contaminants exceed Effects Range Low (None exceed ERM)	<5 contaminants exceed Effects Range Low
Amphipod Toxicity	<80 % Survival	-	=80 % Survival
% of Expected Species Richness Normalized for Salinity	< 75 %	75-90%	> 90%

Table 2. Statewide assessment of coastal bays and estuaries based on water and sediment quality indicators. Assessments are expressed as percent area* (from *National Coastal Condition Report II*, U.S. EPA, 2004).

Water Quality Indicators	Low Quality	Moderate Quality	High Quality
Dissolved Oxygen	0	2	98
Nitrogen	1	12	87
Phosphorus	2	46	52
Chlorophyll *a*	0	13	87
Water Clarity	24	11	65
Sediment Quality Indicators	**Low Quality**	**Moderate Quality**	**High Quality**
Total Organic Carbon	1	3	96
Sediment Contamination	7	57	36
Amphipod Toxicity	<1	-	>99
Species Richness	7	15	78

* Results are based on data collected as part of the EMAP-Coastal Waters program. Sites were selected using a statistical sampling design in which every element of the population has a known probability of being selected. The sites were intended to be representative of all estuarine waters of the state.

Dissolved Oxygen

DO in water is essential for all estuarine species, with low oxygen resulting in a stressful environment. Low dissolved oxygen levels are often triggered by large algal blooms fueled by abnormally high nutrient levels. Dissolved oxygen measurements were collected in vertical casts at regular intervals from the surface to bottom using a probe meter; the data presented in this report represents 0.5 meters off the bottom.

Approximately 98% of the estuarine area had DO concentrations greater than 5 mg/L. Dissolved oxygen levels were not less than 2 mg/L in any of the bottom waters in California's estuaries.

Nutrients

Nitrogen in estuaries is understood to be the important limiting nutrient for controlling eutrophication. Phosphorus may also become limiting in estuarine areas if total nitrogen becomes abundant (U.S. EPA, 2003). Excess nutrients can come from wastewater treatment plants, septic systems, fertilizer runoff from farms and lawns, as well from other sources. On the West Coast, nutrients may also come from deep offshore water upwelling along the coast during dry months in summer, and from coastal watersheds during periods of high rainfall in winter. Nutrient chemistry analyses of filtered and preserved water samples were used to measure dissolved nitrogen and phosphorus levels.

Dissolved inorganic nitrogen (nitrate + nitrite + ammonia) concentrations were uniformly low. Less than 1% of waters had concentrations greater than 1.0 mg/L. Approximately 87% of the area had concentrations less than 0.5 mg/L. The few high nitrogen levels were observed at Alviso Slough (South San Francisco Bay) and at the mouths of the Pajaro River (Central California) and the Santa Ynez River (Central California). Approximately

52% of the estuarine waters had dissolved inorganic phosphorus levels less than 0.01 mg/L. The higher values were observed in much of San Francisco Bay and in a few coastal estuaries (Santa Ynez River, Los Angeles Harbor, Santa Margarita River and San Diego Bay).

Chlorophyll *a*

Chlorophyll levels measure the abundance of phytoplankton (microscopic algae). High concentrations of chlorophyll *a* indicate overproduction of algae, which can cause decreased clarity, depleted oxygen, and harmful algal blooms. Nutrient levels impact phytoplankton growth. Chlorophyll levels were measured using filter samples and spectrophotometric analysis.

Chlorophyll *a* concentrations in estuarine waters were generally low, approximately 87% of the area with concentrations less than 5 _g/L. The few high values in summertime chlorophyll concentrations occurred in the Santa Ynez River and in Wilson Creek (northern California).

Water Clarity

Water clarity is a measure of light penetration (the amount and type of light penetrating water to a depth of one meter). Reduced clarity can impair normal algae and other submerged vegetation growth, and is often associated with eutrophic conditions, algal blooms, and storm-related events that cause sporadic erosion. Light penetration data were collected using a Li-Cor point-in-time measurement of light transmission or using a Secchi disc. Li-Cor measurements were taken at the surface and at depth intervals of 0.5 meters to near bottom, except in very shallow areas where smaller depth intervals were used. Light penetration at 1 meter from the surface, expressed as a percent of surface illumination, was either directly measured or computed from measurements at other depth intervals within the water column.

Approximately 24% of estuarine waters had low water clarity. Locations with low water clarity were widely distributed in San Francisco Bay and among the coastal estuaries. The large tidal amplitude found in many estuaries along the West Coast may naturally generate high levels of turbidity in the water column.

Total Organic Carbon

Total organic carbon (TOC) is a measure of the concentration of organic matter in the sediments. High TOC values (5%) can arise from organic waste from point sources or from algal blooms. TOC can also sequester or chelate organic compounds and some metals and make them less biologically available for uptake. Measurements were made using standard sediment analysis of the percent TOC.

TOC concentrations in sediments were generally low. Approximately 96 percent of the estuarine area had TOC concentrations less than 2%. Less than 1 percent of sediments exhibited TOC measurements greater than 5%. The highest levels of TOC were found in Big Lagoon (Northern California) and the Dominguez Channel (Southern California).

Sediment Contamination

Sediment concentration measurements of approximately 80 contaminants, including 24 PAHs, 22 PCBs, 19 pesticides, and 15 metals were taken at each site. Homogenized samples were analyzed using standard wet chemistry and mass spectroscopy. Sediment condition related to contamination was rated moderate if five or more ERLs were exceeded and high if one or more ERMs were exceeded. Based on the literature evaluated, these values identify threshold concentrations that, if exceeded, are expected to produce ecological or biological effects. The sediment contaminant index for the West Coast excluded nickel and the PAH phenanthrene. Phenanthrene was excluded because values were not included from all West Coast sites. Nickel was excluded because the ERM value has a low reliability for West Coast conditions where high natural crustal concentrations of nickel exist (Long, MacDonald, Smith and Calder, 1995).

Seven percent of California's estuarine sediments had high sediment contamination. Moderate contamination (exceeding ERL guidance values for at least five contaminants) was observed in 57% of estuaries. Areas of California with the highest sediment contamination were in Southern California, particularly Los Angeles Harbor.

Sediment Toxicity

Sediment toxicity depends on the biological availability of contaminants in sediments. Sediment toxicity is determined by tests that expose organisms to sediments from each location and evaluate the effects on the organisms' survival. Sediment toxicity tests (10-day static tests) were conducted using the benthic amphipod *Ampelisca abdita*. Sediments were determined to be toxic if there was more than 20% mortality, corrected for controls.

Less than 1% of estuarine sediments in California were found to be toxic (greater than 20% mortality). Toxic sediments were observed in the Dominguez Channel leading into Los Angeles Harbor, as well as in some of the northern California small river mouths. No sediments from San Francisco Bay were found to be toxic to *Ampelisca*, though sediment toxicity tests run with other species of test organisms indicated that some sediments from San Francisco Bay were toxic. Other test species, such as *Eohaustorius estaurius*, may be more representative test species for California.

Species Richness

Benthic communities are largely composed of macroinvertebrates, such as annelid worms, mollusks, and crustaceans. These organisms inhabit the bottom substrates of estuaries. They are an important food source for bottom-feeding fish, invertebrates, ducks, and birds. Communities of benthic organisms are sensitive to pollutant exposure (Holland, Shaughnessey and Heigel, 1988, 1987; Boesch and Rosenberg, 1981; Sanders, Grassle, Hampson, Morse, Gerner-Price and Jones, 1980; Pearson and Rosenberg, 1978; Rhoads, McCall and Yingst, 1978) and as a result are important indicators of environmental stress. The condition of benthic communities on the West Coast was assessed using a benthic indicator consisting of the deviation of species richness from an estimate of expected species richness. The expected species richness was based on a significant regression between number of species and bottom salinity (U.S. EPA 2001, 2005). Sites with species richness of less than 75% of the lower 95% confidence limit were rated as "low," while sites having species richness of 75% to 90% of expected diversity were rated "moderate."

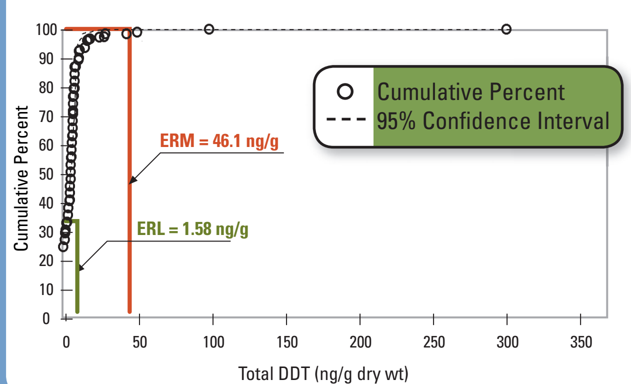
Benthic condition in California's small estuaries overall were observed to be in "good" condition. Only about 7% of the estuarine area had low species richness. Within that 7%, 10% of sites also exhibited degraded sediment quality, and 10% exhibited degraded water quality. More sophisticated benthic indices are being developed for California as part of the sediment quality objectives work (see Box 4).

BOX 3. CUMULATIVE DISTRIBUTION FUNCTIONS

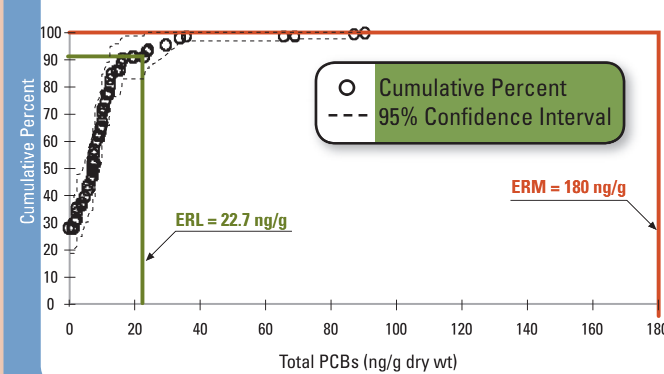
Condition assessments based on the probabilistic EMAP coastal and inland surface waters surveys can be presented as pie charts depicting the percentages of area above or below some threshold (as in Chapter 4, for example). "Cumulative distribution functions," or CDFs, are another way to display the data. The CDF allows for a fuller display of the data, can incorporate statistical confidence in the estimates, and allows the viewer to evaluate the data relative to multiple thresholds.

The examples shown here are CDFs for DDTs and PCBs in estuarine sediments. These data can be compared to NOAA sediment guidelines such as the Effects Range Low (ERL) and the Effects Range- Median (ERM).

Sediment DDT Concentration in California Estuaries



Sediment PCB Concentration in California Estuaries



Approximately 65% of estuarine sediments have DDT concentrations that exceeded the ERL, but only 1% that exceeded the ERM. The conclusion is that there is widespread low-level contamination of DDT but high concentrations are relatively rare. Only about 9% of the estuarine sediments have PCB concentrations that exceeded the ERL.

These CDFs provide an unbiased snapshot of chemical concentrations in estuarine sediments throughout the state and provide perspective for local monitoring programs.

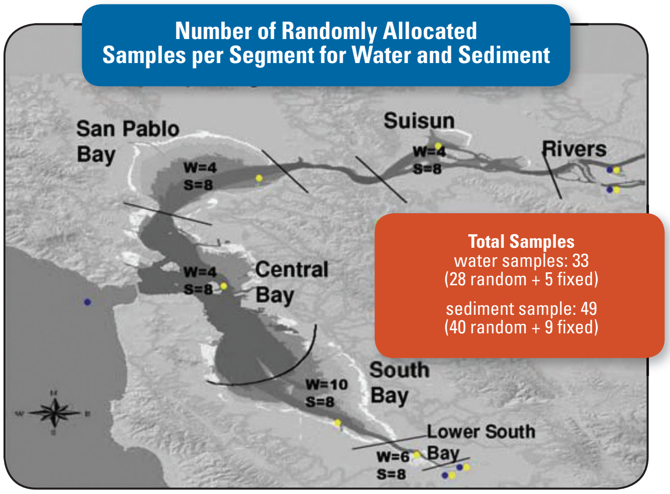


Figure 2. San Francisco Estuary and segments monitored by the Regional Monitoring Program.

B. REGIONAL CONDITION SURVEYS

1. San Francisco Estuary Regional Monitoring Program

The Regional Monitoring Program (RMP) of the San Francisco Estuary is an innovative program initiated by the San Francisco Bay Regional Water Quality Control Board (Water Board) to provide answers to questions needed to manage water quality in the San Francisco Estuary. The program is a partnership between the Water Board, regulated entities that discharge in to the Estuary, and the San Francisco Estuary Institute (SFEI). Permitted groups, including publicly owned treatment works (POTWs), dredgers, stormwater dischargers and industrial dischargers, provide funding for the program. The San Francisco Estuary Institute administers and manages the program, and conducts many of the studies. The geographical extent of the RMP ranges from the Lower South Bay sloughs and tributaries to directly beyond the confluence of the Sacramento and San Joaquin Rivers upstream from Chipps Island (Figure 2).

The RMP consists of three components: status and trends, pilot studies, and special studies. From 1993 to 2001, the status and trends component used a directed sampling design to measure concentrations of contaminants in water, sediment and bivalves. Water and sediment were also evaluated for toxicity using toxicity tests. In 1997, the RMP started to measure contaminants in fish that are caught and consumed by people who fish in the Estuary. Fish contaminant studies have been conducted every three years. Since aquatic toxicity results showed that toxicity in the water column was related to runoff events, monitoring for episodic toxicity was added to the status and trends component of the program.

In 2002, a probabilistic sampling approach was adopted for sediment and water samples. The statistical design is similar to EMAP. Previous to 2002, samples were collected seasonally. Currently, water, sediment, and bivalve samples are only collected during the summer, the most stable period, so that trends can be more easily detected. Toxicity and loading studies are conducted during winter runoff.

Many pilot and special studies have been conducted including studies on: atmospheric deposition of mercury, sediment budgets, fish consumption, sources and loadings of mercury and organic contaminants, predictive modeling of PCB concentrations under various scenarios, contaminant concentrations in bird eggs, emerging contaminants, and effects studies to determine if contaminants in the Estuary are having an effect on bird hatchability, harbor seals, fish or benthic invertebrates. Many of these studies are conducted to support TMDLs.

The RMP has shown that the two main contaminants of concern in the Bay are mercury and PCBs. Both of these contaminants are at concentrations high enough to warrant a fish consumption advisory. Contaminants in the advisory also include dieldrin, chlordane, DDT and dioxins. Concentrations of chlorinated pesticides in fish seem to be slowly declining. Fish are contaminated throughout the Bay; however, the highest concentrations of mercury and PCBs in the sediment and the water column are in the Lower South Bay.

During the 1990s, aquatic toxicity was documented in association with runoff events. This toxicity was thought to be due to the organophosphate pesticides diazinon and chlopyrifos. Since the use of these pesticides has been restricted, toxicity in the water column has decreased. Subsequent studies have indicated that pyrethroid pesticides, which are replacing organophosphate pesticides, may be causing toxicity in the sediment of some tributaries. Toxicity testing in the Bay over the past 10 years has found that about 13% of water samples and 58% of sediment samples were toxic to at least one species tested. Sediment toxicity in the Bay seems to be due to the synergistic effect of contaminant mixtures.

Copper was a major concern in the Estuary in the 1990s, as concentrations were frequently detected above the water quality objective. A stakeholder process was initiated to develop site-specific objectives for copper and nickel and to decrease loadings of copper. Nickel is geologically enriched in the area and not thought to be toxic. New site-specific objectives were developed that were protective of beneficial uses. In 2003, only 1 water sample out of 28, at the boundary of the South Bay and Lower South Bay segments, had a concentration exceeding the water quality objective.

Emerging contaminant studies, in the RMP and in coordination with other researchers, have shown that polybrominated diphenyl ethers (PBDEs) are higher in Bay Area bird eggs than in any other area measured throughout the world. Additional studies are being conducted to identify the sources and fate of this contaminant. These high quality studies, conducted through the RMP, have been extremely valuable in providing certainty for regulators and the regulated community in the identification, prioritization and management of water quality problems.

2. Central Coast Long-Term Environmental Assessment Network

The Central Coast Long-Term Environmental Assessment Network (CCLEAN) is a unique monitoring partnership between ocean dischargers in the Monterey Bay area, working in collaboration with the Central Coast Ambient Monitoring Program. Participants include the City of Santa Cruz, City of Watsonville, Carmel Area Wastewater District, Monterey Regional Water Pollution Control Agency, and Duke Energy. The program is designed to assess loads of contaminants from the four major treatment plant discharges and the four major rivers (San Lorenzo, Pajaro, Salinas and Carmel) entering the Monterey Bay National Marine Sanctuary, and to evaluate impacts in nearshore areas.

The program began sampling in 2001 and is entering its fifth year. Thirty-day flow-proportioned samples are collected from the effluent discharges and the river mouths, and tested for persistent organic pollutants. In collaboration with local agency monitoring efforts, monthly grab and flow sampling is conducted in 14 creek and river mouths. Samples at these sites are analyzed for various constituents including nitrate, orthophosphate, ammonia, dissolved silica, total suspended solids and bacteria. At five sites around the edge of the bay, mussel tissue is sampled for persistent organic pollutants (POP) and bacteria. Four background sites and four depositional sites are sampled for sediment chemistry and benthic infauna composition. The sampling sites are shown in Figure 3. The data summarized below are from the 2003-2004 annual CCLEAN report (available online at [http://www.cclean.org]).

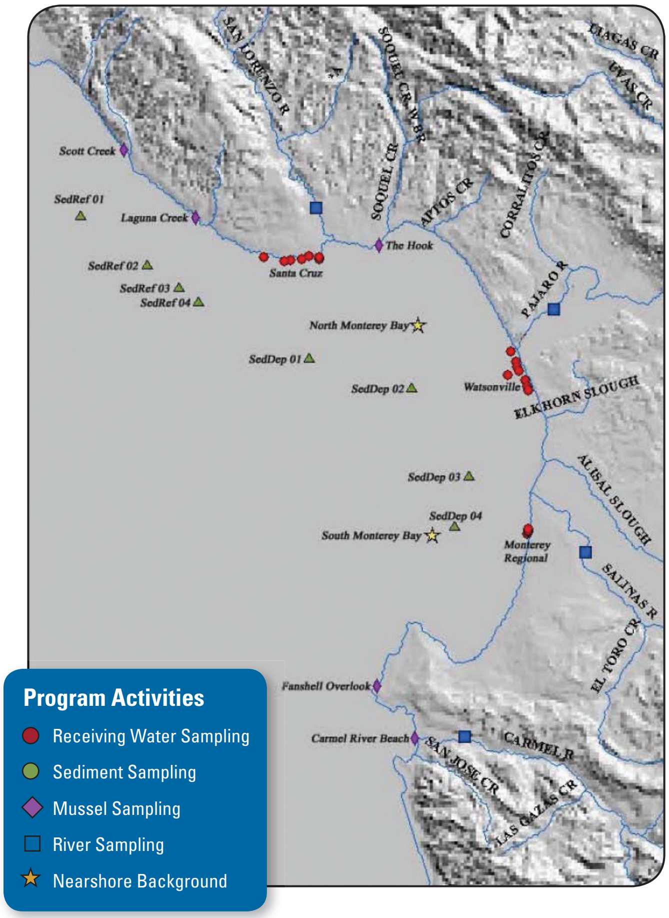


Figure 3. Sampling locations monitored by the Central Coast Long-Term Environmental Assessment Network.

Persistent Organic Pollutants

Analysis of 30-day effluent discharge samples indicates that concentrations of persistent organic pollutants (POP) from treatment plants were low, ranging in the parts per trillion or less. Polynuclear aromatic hydrocarbons were present in greater concentration (up to 92.9 ng/L) than the other persistent organic pollutants. Other contaminants, including chlordane, hexachlorcyclohexanes (HCHs), DDTs, and PCBs, were also detected.

In contrast, much higher overall loads of POP were detected in the 30-day samples collected from the river mouths. The annual load of DDT from the Pajaro and Salinas rivers accounted for 99% of the total annual load of 11, 838 grams from both rivers and wastewater discharges. Dacthal, an agricultural herbicide, was found in the Pajaro and Salinas Rivers at levels that were 23 to 500 times greater than in either of the other rivers or any of the wastewater discharges. The distribution of DDT and Dacthal concentrations in sediment and mussels were consistent with the highest loads occurring in the wet season and originating near the apex of the Bay, where the Salinas and Pajaro rivers enter.

In general, POP levels in mussels were higher in wet-season samples. Levels of POPs (DDT, chlordane, and dieldrin) exceeding several guideline values, including Mussel Watch Elevated Data Levels and Maximum Tissue Residual Levels, have been found in mussel samples from the Hook and Laguna in multiple sampling years.

Levels of DDT found in sediments in nearshore areas consistently exceeded the NOAA Effects Range Low guideline value. Analysis of historical data indicates that only one of the eight nearshore sites has shown a significant decline in DDT concentrations from levels documented in 1970. Statistical analysis of benthic infauna samples showed a significant relationship between densities of several species and POP concentrations. Additional years of data will be needed to substantiate this finding.

Nutrients

The collaborative sampling effort in streams and rivers generates monthly data from 14 of the largest watersheds entering Monterey Bay. "Loadings" have been estimated in six of these sites. Load is calculated by averaging all 12 monthly daily load values and multiplying by 365. These estimates should be considered screening level evaluations because of the low sampling density, particularly associated with storm events. Limited data from storm events probably results in a conservative estimate of load. In spite of this, the highest loads of nutrients occurred in the wet season, from December through March. Nitrate nitrogen loads leaving rivers ranged as high as 139,000 kg/yr from the Pajaro River. In contrast, nitrate nitrogen loads from effluent discharges ranged from 5,114 kg/yr to 67,330 kg/yr. River loads of orthophosphate ranged from 556 kg/yr to 29,200 kg/yr, and ammonia ranged from 2,910 to 5,390 kg/ yr. Orthophosphate loads from discharges ranged from 6,276 to 289,355 kg/yr, and ammonia ranged from 5,847 to 395,147 kg/yr. For most parameters, discharges from the six rivers and streams with flow data contribute significantly larger loads to the Bay than wastewater treatment plant discharges. However, loads of ammonia and orthophosphate from treatment plants were substantially higher than from these rivers and streams. The highest average concentrations of nitrate nitrogen, orthophosphate, ammonia and urea were found in Tembladero Slough, tributary to Moss Landing Harbor. For example, average nitrate nitrogen concentration in this system was 22.4 mg/L. This system has been severely impaired by agricultural activities in the area.

Bacteria

Of the 14 rivers sampled, the Salinas River had the highest annual load of total coliform bacteria, whereas the San Lorenzo River had the highest loads of E. coli and enterococcus. The highest loads of bacteria occurred in the wet season, from December through March. The highest pathogen indicator levels in mussels occurred in winter as well, with both Fanshell Overlook near Pacific Grove and Carmel River Beach exceeding the Food and Drug Administration guidelines for fecal coliform in shellfish.

3. Southern California Bight Project

The Southern California Bight is the 700 km (400 miles) of recessed coastline between Point Conception in Santa Barbara County and Cabo Colnett, south of Ensenada, Mexico. The dramatic change in the angle of the coastline creates a large backwater eddy in which subtropical waters flow north nearshore and subarctic waters flow south offshore. This unique oceanographic circulation pattern creates a biological transition zone between warm and cold waters that contains a diverse array of fish and invertebrate species. The area is also one of the most densely populated coastal regions in the country, with nearly 20 million people inhabiting coastal Southern California.

In 1994, a cooperative sampling effort of 12 organizations resulted in the first "snapshot" of the state of the Southern California Bight. In 1998, a comprehensive assessment of the ecological condition of the Southern California Bight was conducted. This effort included 62 organizations. In addition to all areas sampled in the 1994 study, nearshore habitats (bays, harbors and beaches), and offshore islands were also sampled (Figure 4). The "Bight '98" program included three components: Coastal Ecology, Shoreline Microbiology and Water Quality. We summarize below the results of the Coastal Ecology component.

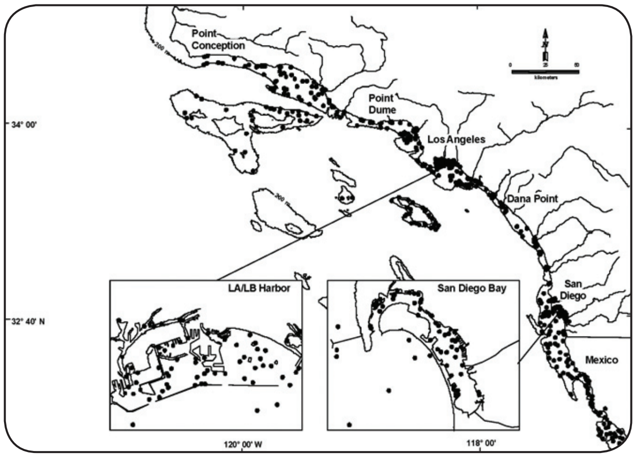


Figure 4. Sampling sites monitored for the Southern California Bight '98 Project.

The goal of the Coastal Ecology Component was to assess the condition of the living marine resources in the Bight and evaluate effects of their exposure to pollutants. The complete assessment reports are available at [http://www.sccwrp.org/regional/98bight/98docs.html]. Three types of indicators of coastal condition were used in Bight '98: chemical exposure (sediment and tissue), health of living resources (benthic macrofauna and demersal fish), and toxicity.

Pollutant Exposure

Approximately 86% of the Southern California Bight had detectable levels of contamination resulting from human activities. Consistent with previous regional surveys, the chlorinated pesticide DDT and its breakdown products, found in detectable levels in 82% of the Bight, were the most widespread. The use of DDT was banned in 1972, andmost of the DDT reflected historical discharges. Enrichment of other contaminants (PAHs, PCBs, and trace metals) generally occurred in less than half of the region. Sediment contamination was not equally distributed, with a disproportionate amount occurring within bay/harbor areas and in the vicinity of Publicly Owned Treatment Works (POTW) discharge zones. Although detectable levels of pollution were widespread, sediment contaminant concentrations were generally below levels expected to cause adverse biological impacts.

Sediment Toxicity

Eighty-one percent of the Southern California Bight contained sediment for which there was no toxicity concern. Three percent of the sediment showed high concern; causing high mortality (50%) to a test species or toxicity to multiple species. The remaining 16% had potential toxicity concern, causing either less severe effects or producing toxicity in only a single test. The greatest prevalence and severity of toxicity was present in port and marina areas within bays and harbors, where 35% of the area was of either potential or high concern. Toxicity was also detected in 22% of less developed bay habitats, but the effects were generally moderate. The extent of toxic concern within POTW and other coastal habitats were similar to one another (22% and 17%, respectively) and much less severe compared to port and marina areas. Sediments near river mouths showed the least extent of toxicity (13% of the area), although most of the toxicity was of high concern. All of the high concern river mouth sites were located near the Los Angeles River, which discharges behind the Long Beach Harbor breakwater, where calm waters enhance the deposition of contaminated sediments.

Benthic Infauna

Eighty-eight percent of southern California sediments support benthic communities in reference condition. Another 10% were found to deviate only marginally (response level 1). Macrofaunal communities in the remaining 2% of the Bight exhibited stronger responses, indicating evidence of community disturbance. At each level, fewer and fewer species are able to thrive, and deviation from the reference condition is greater.

Among the major habitats studied, bays and harbors were found to have the highest proportion (17%) of disturbed benthic communities. Disturbed benthic communities were also observed in river mouth and offshore wastewater discharge areas, but the extent of disturbance in these areas was not substantially different from that in other open coastal areas. The islands were free of areas with disturbed communities. Nonindigenous species were found to be ubiquitous and disproportionately abundant within bays and harbors, occurring in 121 of 123 of the bay and harbor sites sampled. They were found in all major industrial harbors and almost all the small recreational harbors. Little evidence was found that they were causing major disruption in the species richness or organism abundance of the native communities they have invaded despite the prevalence of nonindigenous species. Their effects on individual native species were not examined in this study, but given the observed prevalence in southern California's bay and harbors, the Bight report suggests this should be a focus of future studies.

Demersal Fish

Demersal fish, fish living on or near the bottom, are good indicators of pollution effects because they live on the sediments where contaminants often accumulate. They generally have low mobility and are responsive to local sources of contamination. These responses can include elevated tissue contaminant levels, prevalence of diseases or disrupted communities. Demersal fish communities were found to be healthy in the 1998 study, with normal (reference) communities found in 97% of southern California. The few sites having communities that differed from reference were located near river mouths. The levels of diseases and parasites were low.

C. LESSONS LEARNED AND NEXT STEPS

Assessments based on statewide Coastal EMAP data suggest that most of the state's coastal waters appear to be in "fair" to "good" condition using a suite of key water and sediment quality indicators. Sediment contaminant concentration, one of the sediment quality indicators, was found to be in "moderate" to "high quality" condition in more than 90% of the state. This indicator suggested "poor" conditions at less than 10% of the state; these areas tended to be in Southern California ports. This estimate may change depending on the results of a more comprehensive evaluation currently being undertaken as part of the development of sediment quality objectives for California.

The results for California are comparable to West Coastal and national results reported in the National Coastal Condition Report (Table 3; U.S. EPA, 2004). The West Coastal study area extends from the Washington-Canada border to the Mexican border. The national assessment applies to 28 coastal states and Puerto Rico. The threshold values used to evaluate the California data are the same ones used in the national coastal assessment. While these thresholds do not necessarily reflect water quality standards or thresholds of concern for California, they are used for assessment purposes because thresholds have not yet been established for these indicators in California.

Table 3. Comparison of assessments for California, the West Coastal areas, and national coastal areas, expressed as percent area* (from *National Coastal Condition Report II*, U.S. EPA, 2004).

Indicator Type	Condition Category	Region		
		California (%)	West Coastal (%)	National (%)
Water Quality Indicators				
Dissolved Oxygen	*High Quality*	98	74	76
	Moderate Quality	2	25	20
	Low Quality	0	<1	4
Nitrogen	*High Quality*	87	>93	82
	Moderate Quality	12	7	13
	Low Quality	1	<1	5
Phosphorus	*High Quality*	52	4	53
	Moderate Quality	42	86	38
	Low Quality	2	10	9
Chlorophyll *a*	*High Quality*	87	81	51
	Moderate Quality	13	19	41
	Low Quality	0	<1	8
Water Clarity	*High Quality*	65	48	62
	Moderate Quality	11	16	13
	Low Quality	24	36	25
Water Quality Indicators				
Total Organic Carbon	*High Quality*	96	89	77
	Moderate Quality	3	11	20
	Low Quality	1	0	3
Sediment Contamination	*High Quality*	36	79	85
	Moderate Quality	57	18	8
	Low Quality	7	3	7
Amphipod Toxicity	*High Quality*	>99	83	94
	Moderate Quality	-	-	-
	Low Quality	<1	17	6
Species Richness	*High Quality*	78	72	70
	Moderate Quality	15	15	13
	Low Quality	7	13	17

* Results are based on data collected as part of the EMAP-Coastal Waters program. Sites were selected using a statistical sampling design in which every element of the population has a known probability of being selected. The sites were intended to be representative of all estuarine waters of the region.

Assessments from three large-scale monitoring programs provide more specific information for the San Francisco Bay, the Central Coast, and the Southern California Bight:

- **San Francisco Bay:** The two main contaminants of concern in the San Francisco Bay based on assessments by the Regional Monitoring Program are mercury and PCBs, and these contaminants were found at high enough concentrations to warrant a fish consumption advisory.
- **Central Coast:** Assessments by the Central Coast Long-term Environmental Assessment Network suggest a strong seasonal component to loading of persistent organic pollutants, nutrients, and bacteria, with the greatest loads detected during the wet season, generally from December through March.
- **Southern California Bight:** The health of living resources based on biotic assemblages was generally found to be "good." Sediment contaminant concentrations were generally detected below levels expected to cause adverse biological impacts. Eighty percent of the Southern California Bight contained sediment for which there was minimal to no toxicity concern. The greatest prevalence and severity of toxicity was in port and marina areas within bays and harbors.

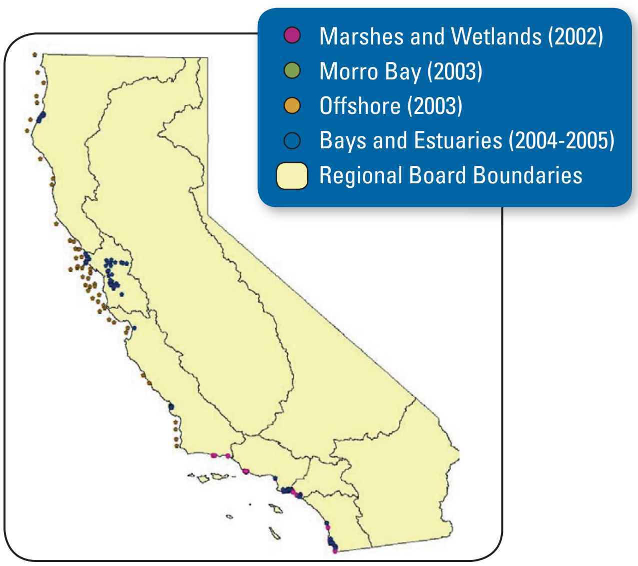


Figure 5. Sites sampled in California for the EMAP-Coastal Waters program from 2002-2005. Sites to be sampled for bays and estuaries in 2006 are not shown. Sites were selected using a statistical sampling design in which every element of the population has a known probability of being selected. The sites were intended to be representative of all estuarine waters of the state.

Assessments of California coastal waters will be continued through Coastal EMAP sampling. Bays and estuaries, intertidal wetlands, and offshore coastal waters have been or are slated to be monitored in 2002 through 2006 (Figure 5). As part of this program, monitoring to assess the status of Morro Bay was conducted in 2003. The remaining Central Coast harbors (Santa Cruz, Moss Landing, Monterey, Port San Luis, and Santa Barbara) were sampled in 2004 to provide a complete Central Coast harbor assessment. It is anticipated that the National Coastal Assessments will occur at five-year intervals, and will be integrated with local and regional monitoring programs.

In addition to condition assessments generated through the EMAP efforts, the information provided in the National Coastal Assessments will be used to track trends in water quality improvement.

Data collected through the EMAP-Coastal Waters program have contributed to California's progress in developing sediment quality objectives (see Box 4). While we have presented the results for the various sediment quality indicators, without sediment quality objectives, interpretation of these different sediment contaminants is challenging.

BOX 4. DEVELOPMENT OF SEDIMENT QUALITY OBJECTIVES IN CALIFORNIA

A benefit of the partnership between the U.S. EPA National Coastal Assessment and the states is the development of assessment tools. The California Water Board is required by state law to develop sediment quality objectives (SQOs); a task that has proven difficult both for EPA nationally and for many individual states throughout the country. California is making progress on developing sediment quality objectives in large part because of the data generated through probability-based, regional monitoring efforts supported by EMAP, the EMAP Western Pilot Project, and the National Coastal Assessment beginning in 1994.

To assess direct effects, California is proposing to use a multiple lines of evidence approach to sediment quality objectives, based upon a measure of exposure and two measures of biological condition. The three indicators that are being proposed are sediment contaminant concentrations, sediment toxicity, and benthic community condition. Data from bays and estuaries on the west coast collected as part of the EMAP Western Pilot Program have provided an unbiased, synoptic dataset to test various approaches. These data have been merged with other high quality, site-specific datasets. Approximately half of the data is being used to evaluate the utility of various measures of exposure, toxicity, and benthic community structure to assess sediment condition. The other half of the data set will be used to validate the approach for statewide application.

A summary of the process for developing and ultimately for implementing these sediment quality objectives can be found at [http://www.waterboards.ca.gov].

For more information, contact Chris Beegan at cbeegan@waterboards.ca.gov.

Direct Effects Sediment Quality Objectives

Direct effects SQOs are establishd to protect those organisms that are directly exposed to pollutants in sediments. The goal is to determine if sediment quality is negatively impacting those organisms. A reference condition is used to determine protected or optimal conditions. Because the benthic invertebrates are the focus of direct effects SQOs, three tools, benthic community, sediment chemistry and sediment toxicty will be applied to provide greater confidence in the decision making process.

1

DIRECT EFFECTS SEDIMENT QUALITY OBJECTIVE

An example of a direct effects narrative objective is "Sediment quality shall be maintained at a level that protects benthic invertebrates from degradation caused by bio-available pollutants in sediments."

2

IMPLEMENTATION OF THE NARRATIVE DIRECT EFFECTS SEDIMENT QUALITY OBJECTIVE

A narrative objective must be linked to a methodology that describes how the narrative objective is implemented. Multiple thresholds will be developed for each indicator and used to assess a response at a particular station.

3

EACH STATION WOULD BE ASSESSED USING THREE LINES OF EVIDENCE AND THE TOOL SPECIFIC THRESHOLDS.

Finally a method to integrate the three results will be developed to describe the sediment quality at the station level.

SEDIMENT CHEMISTRY

Response	Threshold
	T^0 tox
	T^1 tox
X	T^2 tox
	T^3 tox
	T^4 tox

BENTHIC COMMUNITY

Response	Threshold
	T^0 chem
X	T^1 chem
	T^2 chem
	T^3 chem
	T^4 chem

SEDIMENT TOXICITY

Response	Threshold
	T^0 ben
	T^1 ben
	T^2 ben
X	T^3 ben
	T^4 ben

NOTES:
The implementation tools cannot be used identify the cause of impairment.
This is the fundamental limiation with these current tools. Before any mitigation or restoration can begin, the stressor must be identified. Although bulk chemistry data can quantify what pollutants are present, thhis data does not provide any information on bioavailability. Many pollutants are bound by organics or anions in the sediment that prevent the pollutant from causing toxicity.

The implementation of the narrative sediment quality objective is based solely on the application of multiple lines of evidence. No single line of evidence should be used in any application because of the limitations associated with either the tool used to quantify the condition or response of the indicator, or limitation associated with the indicator itself.

CHAPTER 3
WADEABLE STREAMS CONDITION

California has more than 211,000 river and streams miles, with more than 64,000 miles estimated to be perennial.[3] Perennial streams contain water year-round. A large percentage of streams in California are ephemeral or intermittent, drying up for part of the dry season, or containing water only after major rain events or for very short times during the year. In this section, we refer to these collectively as “non-perennial” streams. “Wadeable” streams are streams, creeks, and small rivers that are shallow enough to sample without boats. Streams and rivers support aquatic life by providing habitat, spawning grounds, food, and shelter for fish, birds, and other wildlife.

Figure 6. Sites sampled in California for the EMAP-Inland Surface Waters program from 1999-2003. Sites were selected using a statistical sampling design in which every element of the population has a known probability of being selected. The sites were intended to be representative of all wadeable streams of the state.

The condition assessments presented in this section focus on perennial wadeable streams. The statewide and regional assessments are based on biological data, primarily benthic macroinvertebrate data, collected in California as part of the EMAP-Inland Surface Waters program. Local watershed condition assessments for specific watersheds in the Central Coast and Los Angeles areas are based on Regional Water Board data collected under SWAMP.

A. STATEWIDE CONDITION

The statewide and regional ecological condition assessments are based on benthic macroinvertebrate EMAP data. The EMAP-Inland Surface Waters program focused on perennial streams, and was implemented in California from 1999 through 2003. Approximately 50 probabilistically assigned sites per year were sampled. The original design included a base statewide study and two special interest areas in southern coastal and northern coastal California (Figure 6). In 2003, an additional survey was added to increase the representation of sites in the central coast region. These assessments presented in this section were produced as part of the California Monitoring and Assessment Program (CMAP).

Two general types of benthic macroinvertebrate indices are used for estimating the biological condition of wadeable streams: the observed/expected index (O/E index) and the index of biotic integrity (IBI). The O/E index compares the number of taxa expected to exist at a site (E) to the number that are actually observed (O). The taxa expected at individual sites are based on models developed from data collected at reference sites. The IBI is the sum of a number of individual measures (such as pollution tolerance, taxa richness) of

3. Estimates obtained from the 1994 U.S. EPA Reach File Version 3/Digital Line Graph data.

Table 4. Estimated stream lengths (in stream miles) of wadeable perennial streams in California.

Site Status (number of sites)		Estimated Length (miles)
Statewide		
Target	Target, sampled (191)	16,414
	Target, not sampled (30)	4,957
	Inaccessible (57)	6,876
Unknown	(97)	8,893
Non-target	(349)	22,049
Northern Coastal		
Target	Target, sampled (71)	5,129
	Target, not sampled (8)	609
	Inaccessible (23)	1,949
Unknown	(35)	3,136
Non-target	(42)	3,994
Southern Coastal (south and central coast combined)		
Target	Target, sampled (85)	853
	Target, not sampled (8)	135
	Inaccessible (24)	344
Unknown	(45)	345
Non-target	(256)	2,576

biological condition. The individual measures or metrics are summed to comprise the total score. In both cases, the ability to recognize ecological degradation relies on understanding conditions expected in the absence of human disturbance. The percent area falling into each of the categories of condition for each indicator are summarized in Table 5. The assessments do not apply to an equally important subset of streams and rivers in California, those that are non-perennial. This subset is not included in the assessment because suitable indicators are currently being developed. Modified streams, which were not part of population of sites sampled by EMAP-Inland Surface Waters, are also not included in the assessment.

The statewide and regional assessments use statistically established threshold values (Table 6; Ode and Rehn, 2005; Rehn and Ode, 2005; Stoddard, Peck, Olsen, Paulsen, Van Sickle, Herlihy, Kaufmann, Hughes, Whittier, Lomnicky, Larsen, Peterson and Ringold, 2005; California Department of Fish and Game, 2004). These thresholds do not reflect water quality standards or thresholds of concern for California. However, we use them here for assessment purposes since statewide thresholds have not been established in California for these indicators.

Table 5. Statewide and large regional study area assessments of wadeable perennial streams based on aquatic invertebrate indices. Assessments are expressed as percent area.*

Indicator	% Non-Impaired	% Impaired
Statewide		
Macroinvertebrate Index of Biotic Integrity (W-EMAP IBI)	78	22
Macroinvertebrate Observed/Expected Index (California O/E Index)	67	33
Northern Coastal		
Macroinvertebrate Index of Biotic Integrity (North Coast IBI)	94	6
Macroinvertebrate Observed/Expected Index (California O/E Index)	60	40
Southern Coastal (south and central coast combined)		
Macroinvertebrate Index of Biotic Integrity (South Coast IBI)	66	34
Macroinvertebrate Observed/Expected Index (California O/E Index)	67	33

* Results are based on benthic macroinvertebrate data collected as part of the EMAP-Inland Surface Waters program. Sites were selected using a statistical sampling design in which every element of the population has a known probability of being selected. The sites were intended to be representative of all wadeable streams of the region.

Table 6. Aquatic invertebrate indices and threshold values used for statewide and regional study area assessments of wadeable perennial streams.

Indicator	Threshold Value
Statewide	
Macroinvertebrate Index of Biotic Integrity (W-EMAP IBI)	IBI score of <57 (5th percentile) for mountain sites; IBI score of <47 (5th percentile) for xeric sites
Macroinvertebrate Observed/Expected Index (California O/E Index)	O/E score of <0.77; 1.5 standard deviations below an O/E score of 1.0
Northern Coastal	
Macroinvertebrate Index of Biotic Integrity (North Coast IBI)	IBI score of <52; 2 standard deviations below the mean reference score
Macroinvertebrate Observed/Expected Index (California O/E Index)	O/E score of <0.77; 1.5 standard deviations below an O/E score of 1.0
Southern Coastal (south and central coast combined)	
Macroinvertebrate Index of Biotic Integrity (South Coast IBI)	IBI score of <39; 2 standard deviations below the mean reference score
Macroinvertebrate Observed/Expected Index (California O/E Index)	O/E score of <0.77; 1.5 standard deviations below an O/E score of 1.0

Macroinvertebrate Index of Biotic Integrity

In the W-EMAP IBI, the metrics used to represent key characteristics of biological integrity are taxonomic richness, taxonomic composition, taxonomic diversity, feeding groups, habits, and pollution tolerance (Stoddard et al., 2005). Specific metrics for each of these categories were chosen for three climatic regions of the west: plains, xeric, and mountains. Each metric is scored, and then summed to create an overall IBI ranging in value from 0 to 100, with 100 denoting the best observed condition.

Statewide, 22% of the stream length is considered to be in "impaired" condition relative to macroinvertebrate biotic integrity using the W-EMAP IBI (Figure 7).

Macroinvertebrate Observed/Expected Index

The California O/E index developed by Hawkins (unpublished) has a three-class hydro-climatic classification. Class 1 is "wet and cool," class 2 is "dry, warm, and flashy," and class 3 is "mesic and cold." All sites are assigned to the appropriate class based on precipitation and/or temperature. Predictor variables vary according to class.

Statewide, 33% of the stream length was estimated in "impaired" condition with respect to macroinvertebrate biotic integrity using the California O/E index (Figure 7; Ode and Rehn, 2005).

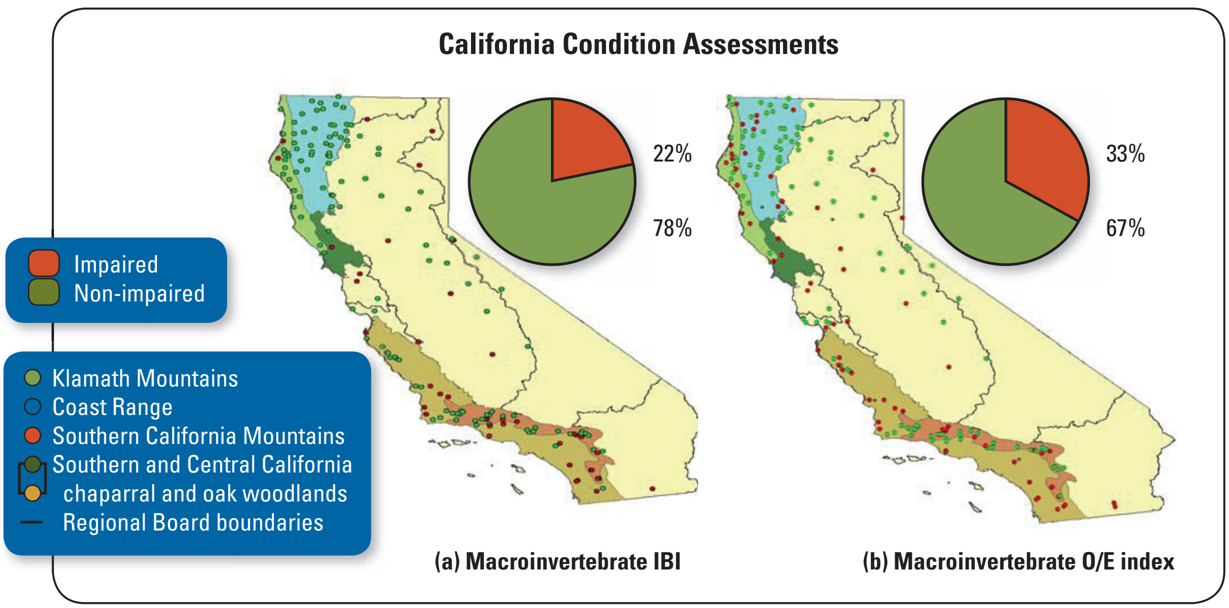


Figure 7. Proportion of stream length statewide in the various condition categories based on the (a) macroinvertebrate IBI, and (b) macroinvertebrate O/E indices. Each site is assigned a "weight" equal to the number of stream kilometers represented by that sample reach. Results are based on benthic macroinvertebrate data collected as part of the EMAP-Inland Surface Waters program. Sites were selected using a statistical sampling design in which every element of the population has a known probability of being selected. The sites were intended to be representative of all wadeable streams of the state.

B. REGIONAL CONDITION

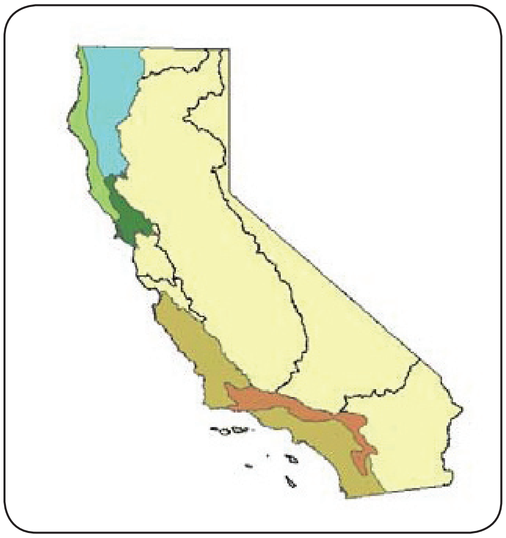


Figure 8. Location of northern coastal and southern coastal areas.

The following regional condition assessments are based on benthic macroinvertebrate EMAP data collected in special study areas in northern coastal and southern (including both central and southern) coastal California from 1999 through 2003 (Figure 8). The central and south coast data were combined to increase the datasets, and assessments for this combined area are presented as part of the "southern coastal" wadeable stream condition assessment.

1. Wadeable Stream Condition in Northern Coastal California

The northern coastal California EMAP study area includes three ecoregions (Coast Range, Klamath Mountains, and Southern and Central Chaparral and Oak Woodlands) and portions or all of two Regional Water Boards (North Coast and San Francisco Bay). It encompasses a region with the highest rainfall totals in California, ranging from nearly 200 inches near the Oregon border to more than 50 inches over mountain ranges in the southern portion. The human population of the area was estimated at 1.04 million in 2004, with Sonoma and Marin counties accounting for over half this total. This total is relatively low compared to other parts of the state. The area also includes 12 percent of the state's land area, but produces 40 percent of the state's total runoff and 48 percent of the private timber harvested within the state.

Macroinvertebrate Index of Biotic Integrity

The North Coast macroinvertebrate IBI was developed for the region that drains directly west to the Pacific Ocean from the Oregon border in the north and Marin County in the south (Rehn and Ode, 2005). The final eight metrics included in the IBI represent several metric types including taxonomic richness, taxonomic composition, tolerance measures, and functional feeding groups. Each metric is scored then summed to create an overall IBI ranging in value from 0 to 100. For six of the eight metrics, separate scoring scales are used for the three ecoregions.

For the northern coastal California region, more than 90% of the wadeable stream length was considered "non-impaired" with respect to macroinvertebrate biotic integrity using the North Coast IBI (Figure 9; Rehn and Ode, 2005).

Macroinvertebrate Observed/Expected Index

The California O/E index used is the same one developed by Hawkins (unpublished) and described under the "Statewide Condition" section of this chapter. An estimated 60% of the wadeable stream length was found to be "non-impaired" with respect to biotic integrity using the California O/E index (Figure 9; Ode and Rehn, 2005).

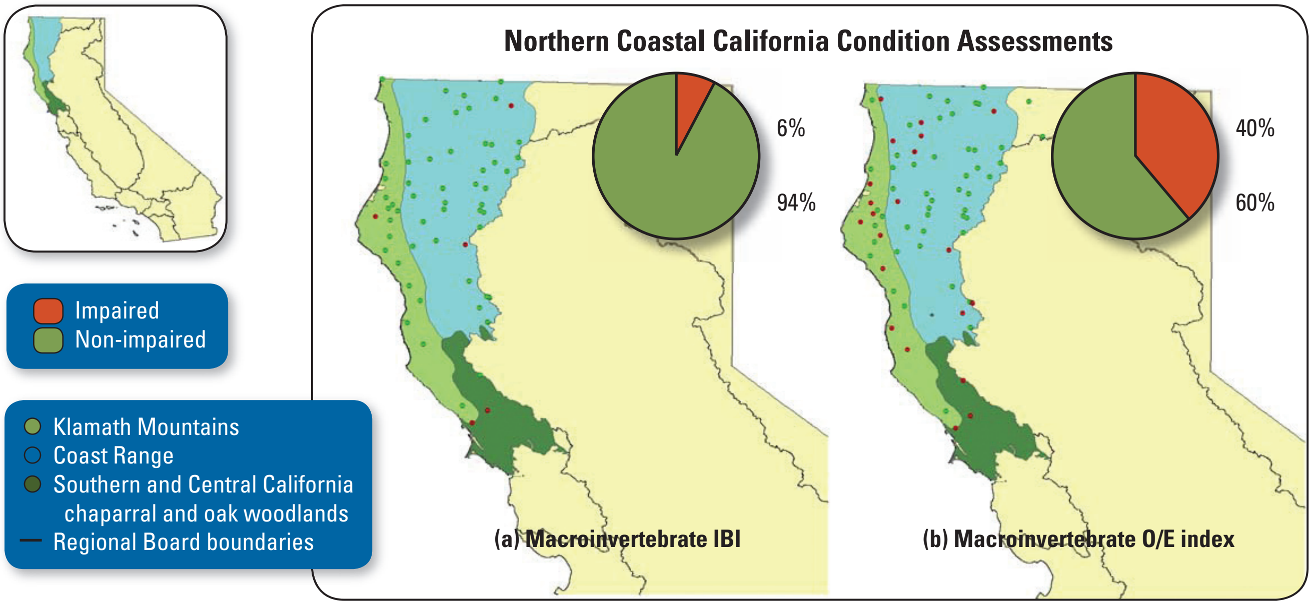


Figure 9. Proportion of stream length in the northern coastal area in the various condition categories estimated from (a) macroinvertebrate IBI, (b) macroinvertebrate O/E index. Each site is assigned a "weight" equal to the number of stream kilometers represented by that sample reach. Results are based on benthic macroinvertebrate data collected in the northern coastal study area as part of the EMAP-Inland Surface Waters program. Sites were selected using a statistical sampling design in which every element of the population has a known probability of being selected. The sites were intended to be representative of all wadeable streams of the study area.

The O/E index suggests a higher percentage of biotic impairment than the IBI. The difference may be related to how the thresholds were defined. The impairment threshold in the north coast IBI was set at two standard deviations below the mean score of the reference population. When the threshold is set at 1.5 standard deviations below the mean score of the reference population, so that it is equivalent to the threshold used for the O/E index, 15% (as opposed to 6% with the threshold set at 2 standard deviations) of sites are classified as "impaired." Rehn and Ode (2005) also applied an aquatic vertebrate IBI developed for coldwater streams of the Pacific Northwest (Hughes, Howlin and Kaufmann, 2004) to the northern coastal dataset. They found greater than 90% of streams to be in "good" condition based on this index. The northern coastal IBI is in the process of being refined (see "Next Steps" discussion) to account for timber logging practices. The dataset for this study area will need to be re-evaluated in the future using the revised index.

2. Wadeable Stream Condition in Southern Coastal California

The southern coastal California EMAP study area includes two ecoregions (Southern California Mountains, Southern and Central California Chaparral and Oak Woodlands), and portions or all of several Regional Water Boards (Central Coast, Los Angeles, Santa Ana, San Diego, and Colorado River Basin). The area is arid, with precipitation averaging 10 to 20 inches per year in lower elevations, 20-30 inches in upper elevations, and 30-40 inches in the highest elevations and some isolated coastal watershed. The population size of the area, estimated at 22.4 million in 2004, is expected to exceed 28 million by 2025.

Macroinvertebate Index of Biotic Integrity

The South Coast benthic macroinvertebrate IBI was developed for the region bounded by Monterey County in the north, the Mexican border in the south, and inland by the eastern extent of the southern Coast Ranges (Figure 10; Ode et al., 2005). The final seven metrics included in the IBI represent several metric types including taxonomic richness, taxonomic composition, tolerance measures, and functional feeding groups. Each metric is scored then summed to create an overall IBI ranging in value from 0 to 100. For three of the metrics, separate scoring scales are used for the two ecoregions.

For the southern coastal California region, more than 60% of the wadeable stream length was found to be in "non-impaired" condition with respect to macroinvertebrate biotic integrity using the South Coast benthic macroinvertebrate IBI (Figure 10; Rehn and Ode, 2005).

Macroinvertebrate Observed/Expected Index

The California O/E index used is the same one developed by Hawkins (unpublished) and described under the "Statewide Condition" section of this chapter.

More than 60% of the wadeable stream length was found to be in "non-impaired" condition with respect to macroinvertebrate biotic integrity using the California O/E index (Figure 10; Ode and Rehn, 2005).

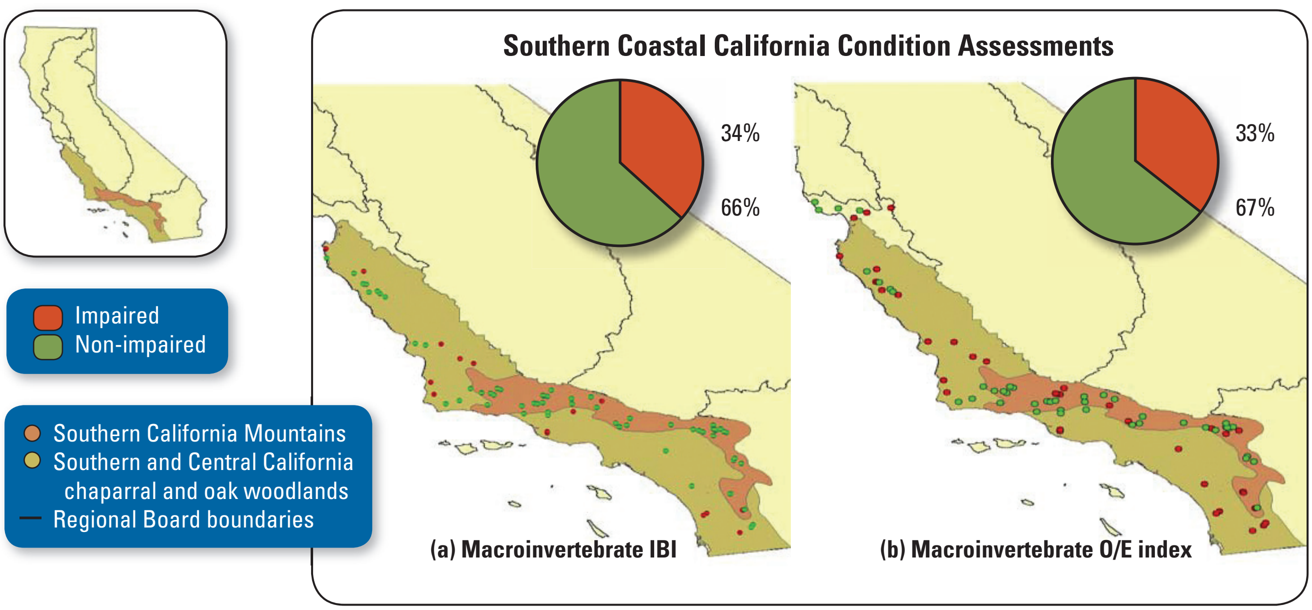


Figure 10. Proportion of stream length in the southern coastal area in the various condition categories estimated from (a) macroinvertebrate IBI, and (b) macroinvertebrate O/E index. Each site is assigned a "weight" equal to the number of stream kilometers represented by that sample reach. Results are based on benthic macroinvertebrate data collected in the southern coastal study area as part of the EMAP-Inland Surface Waters program. Sites were selected using a statistical sampling design in which every element of the population has a known probability of being selected. The sites were intended to be representative of all wadeable streams of the state.

C. LOCAL WATERSHED CONDITION

1. Wadeable Stream Condition in the Santa Clara River Watershed (2001-2003)

The Santa Clara River Watershed is the largest river system in southern California remaining in a relatively natural state. The watershed area is approximately 1,634 square miles and the main river is approximately 100 miles long. Major tributaries include Castaic, San Francisquito, Sespe, Piru, and Santa Paula Creeks. About 40% of the watershed is located in Los Angeles County and 60% is in Ventura County. Much of the watershed lies in mountainous terrain within either the Angeles or Los Padres National Forests.

The SWAMP conducted monitoring of the Santa Clara River Watershed at 38 sites, comprised of 30 randomly selected sites throughout the watershed and 8 targeted sites. The randomized sampling design provides a method for statistically valid assessments of the areal extent of water quality problems within the overall watershed, without the need to sample every stream segment in the watershed. The design was supplemented with targeted sampling to ensure that representative points, generally the base of key subwatersheds, were sampled. Sampling began in 2001 at 10 of the 30 randomly selected sites and at the 8 targeted sites. Sampling continued in 2003 at all 30 randomly selected sites. Monitoring included field measurements, conventional water chemistry, water column toxicity testing, and benthic macroinvertebrates. At the eight targeted sites additional chemical analyses were performed for trace metals, trace organics, and bioaccumulation (freshwater clams).

The overall health of the watershed is discussed in terms of benthic macroinvertebrates, water column toxicity and water column nitrate concentrations. The Water Quality Control Plan for the Los Angeles Region (Basin Plan) contains water quality objectives for the protection of beneficial uses, but it does not specify numerical objectives for these three indicators that would categorize surface waters as being of "high," "moderate," or "low" quality. The rating categories defined below represent an attempt to establish a scale to interpret the condition of the watershed, but these should not be confused with actual water quality standards. The thresholds used are defined in Table 7. The assessments expressed as percent area are summarized in Table 8.

Table 7. Assessment values used to interpret the aquatic life use assessment in the Santa Clara River Watershed.

Indicator	High Quality	Moderate Quality	Low Quality
Macroinvertebrate Index of Biotic Integrity (South Coast IBI)	>40	27-40	<27
Toxicity	No Toxicity	Chronic Toxicity	Acute Toxicity
Nitrate	<1 mg/L	1 to 3 mg/L	>3 mg/L

Table 8. Watershed assessment for the Santa Clara River Watershed based on select indicators. Assessments expressed as percent area (based on 2003 data only).

Indicator	% High Quality	% Moderate Quality	% Low Quality
Macroinvertebrate Index of Biotic Integrity (South Coast IBI)	24	48	28
Toxicity	67	20	13
Nitrate	80	17	3

Bioassessment ratings are based on the index of biotic integrity (IBI) developed for Southern California. Three rating categories are defined: "high" quality (IBI scores of "very good" or "good"), "moderate" quality (IBI score of "fair"), and "low" quality (IBI scores of "poor" and "very poor"). The relative IBI rankings for the sites are shown in Figure 11. Toxicity ratings are based on the results of both chronic and acute toxicity testing with different species. Nitrate ratings are based on the concentrations of nitrate nitrogen measured in water column samples.

Relative IBI Rankings for Santa Clara River SWAMP Sites (2001, 2003)

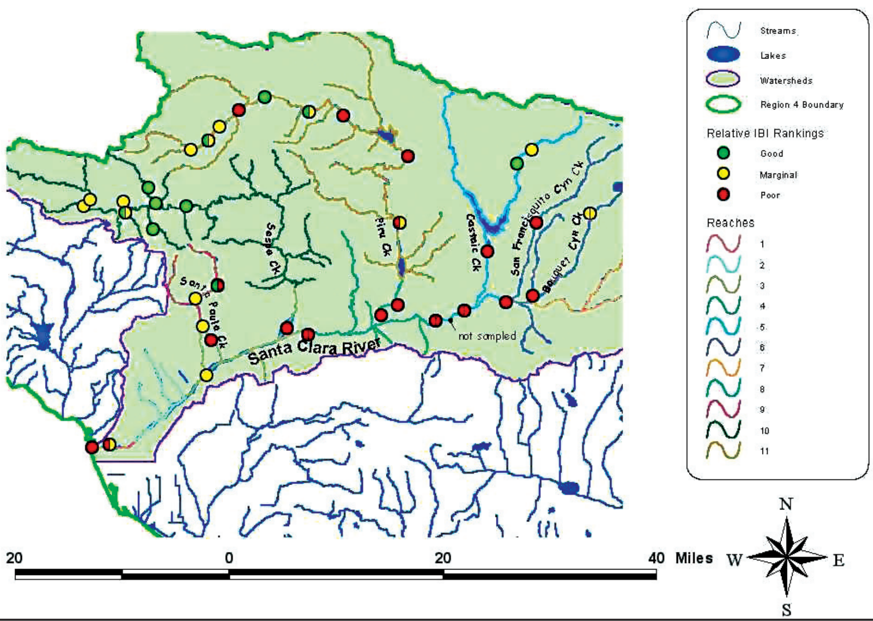


Figure 11. Relative IBI rankings for Santa Clara River SWAMP sites. [Note: Full circles indicate that sites were sampled once, either in 2001 or 2003; half-circles indicate that sites were sampled during both 2001 and 2003. "Good" is defined as "high" quality, "marginal" is defined as "moderate" quality, and "poor" is defined as "low" quality.]

Based on the South Coast IBI, only about 24% of the stream miles support high quality benthic conditions. Roughly 28% of the stream miles have biological communities that can be characterized as "poor" to "very poor." Benthic macroinvertebrate communities were in "low" or "moderate" condition at all of the sampling sites located along the mainstem of the Santa Clara River. This finding was not unexpected, since many of these areas are in urbanized portions of the watershed. However, many of the sites in the tributaries also were of "moderate" and "low" quality, even though many of these areas are in relatively undeveloped portions of the watershed. Sespe Creek was the subwatershed in the best condition, with all ratings falling into the "good" and "moderate" quality classification. Sites from the other subwatersheds were generally rated as "moderate" and "low" quality. In six out of the ten random sites that were sampled twice, the bioassessment ratings were different between years.

Nitrate concentrations were generally low. An estimated 80% of stream miles could be classified as having "high" quality and only 3% of the stream miles could be classified as having "low" water quality with respect to nitrate. The higher concentrations were in the mainstem. All the mainstem samples were characterized as either "low" to "moderate" quality. Nearly all the other sites fell into the high quality classification.

Toxicity results were mixed. Toxicity was observed on at least one occasion at most of the sampling sites along the main stem of the Santa Clara River and at one or more sampling sites in each of the subwatersheds. More than half of the sampling sites in Piru Creek had toxicity, mostly located in the uppermost portion of the tributary.

All monitoring data for the Santa Clara River Watershed has been summarized in a report (Kamer and Fairey, 2005) and is available at [http://www.waterboards.ca.gov/swamp/docs/r4calleguas_scrvrws_swampfinalrpt.pdf].

2. Aquatic Life Use Assessment in the Central Coast Region (1998-2005)

In the Central Coast Region, water quality assessment has been primarily achieved through monitoring activities of the Central Coast Ambient Monitoring Program (CCAMP). This Regional Board program has provided a screening level assessment of water quality in all Hydrologic Units (HU) of the region since 1998, with primary funding now provided by the SWAMP. Monitoring activities are rotated through five watershed areas on an annual basis at 162 sites; 33 additional "coastal confluence" sites are monitored continuously for trends. Monitoring is based on a variety of chemical, physical and biological indicators, and includes monthly sampling for conventional parameters. CCAMP utilizes a "weight-of-evidence" approach to evaluate beneficial use support in surface waters.

Several beneficial uses and criteria that are protective of fresh water aquatic life are identified in the Central Coast Basin Plan. Beneficial use impairments are evaluated using the criteria listed in Table 9 and the Water Board 303(d) listing policy (SWRCB, 2005).

Table 9. Central Coast Region Basin Plan criteria used in beneficial use assessments.

Criteria	Source
Any sediment or water toxicity effect significantly greater than reference tests	Basin Plan general objective
Median % oxygen saturation levels less than 85%	Basin Plan general objective
More than 10% of unionized ammonia samples over 0.025 mg/L as N	Basin Plan general objective
Mean biostimulatory risk rank scores in the 75th percentile of all scores	Interpretive tool for Basin Plan narrative objective
More than 10% of Southern California index of biotic integrity score poor or very poor (<39)	Interpretive tool for Basin Plan narrative objective

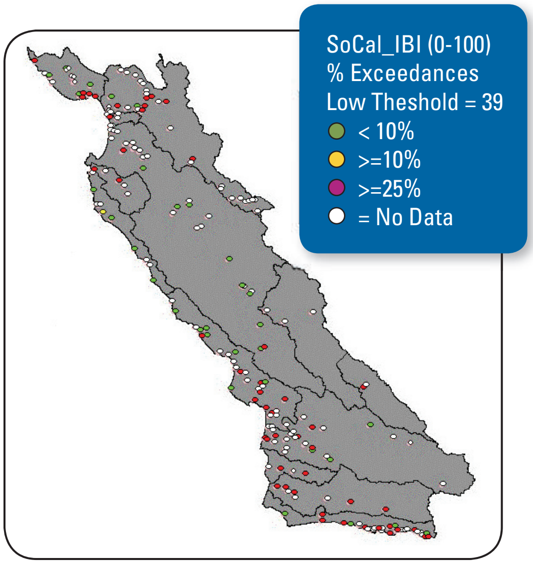


Figure 12. Southern California IBI scores, displayed as percent of scores at each site ranked "poor" or "very poor" (below 39). Minimum sample count is two.

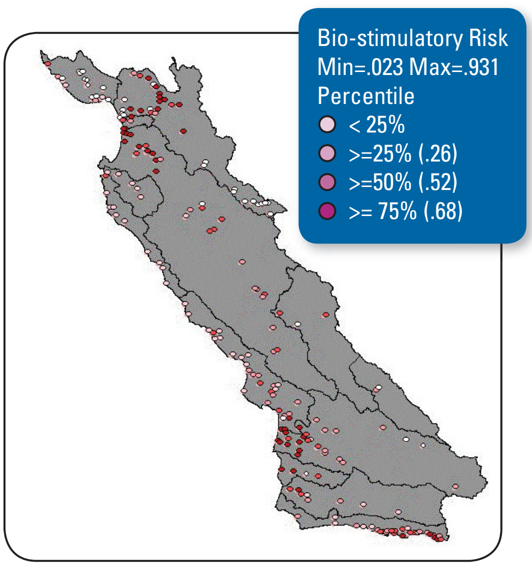


Figure 13. Biostimulatory risk scores displayed in quartiles for ambient monitoring sites in the Central Coast Region. Sites with the highest rank (shown in red) are those with the greatest risk for biostimulation.

Monthly CCAMP data collected at all sites includes nutrients, dissolved oxygen, water temperature and pH. Because these parameters are collected monthly over a 15-month period (January year 1 through March year 2), most sites are represented by a sample count of between 12 and 15. In order to achieve 90% certainty of an exceedance rate of 10%, assessments are only made for waterbodies with more than five samples. At a subset of these sites, biological and toxicity monitoring is also conducted. Biological sampling of benthic invertebrate communities is conducted in two consecutive spring seasons. Toxicity testing has been limited to two water samples per year, with one in the wet season and one in the dry season. Limited sampling has also been conducted for sediment toxicity. Funding has limited the geographic scope of the biological and toxicity tests.

Waters that exceed a numeric criterion (that is, oxygen saturation and unionized ammonia) or have toxicity tests that resulted in significantly reduced survival relative to the control sample are considered to be impaired for aquatic life beneficial uses. Tools that are used to interpret narrative objectives, such as the Biostimulatory Risk Index and the Southern California IBI can also indicate impairment, but should be used with other lines of evidence to define impairment of aquatic life beneficial uses. Several of the Central Coast Region's waters are not supporting aquatic life beneficial uses based on the criteria listed in Table 9.

The South Coast IBI (Ode et al, 2005) was developed incorporating data from the Central Coast and more southerly coastal regions. Scores under 39 are considered "poor" or "very poor." CCAMP bioassessment monitoring sites are shown in Figure 12 with sites scoring "poor" or "very poor" identified in red.

Staff at the Central Coast Region assessed the risk for problems associated with eutrophication using a multi-parameter index. The index simultaneously considers factors which serve as stimuli (nutrient concentrations), in parallel with those which act as responders (algal and plant cover, water column chlorophyll concentrations and range of pH and dissolved oxygen). Some of these measures, such as nutrient or chlorophyll concentrations, serve as metrics based on magnitude alone. For others such as dissolved oxygen and pH, the departure of the measurement from the regional median value is used to calculate the metric. The index utilizes the maximum value from three qualitative estimates of percent cover for rooted plants, filamentous algae and periphyton, to calculate a plant cover metric.

Risk index scores range from 0 to 1.0. Most of the highest scoring sites (those having the highest risk for biostimulation) are found at the lower ends of large agricultural watersheds like the Pajaro, the Salinas, and the Santa Maria rivers (Figure 13). Other problem areas include the Llagas Creek watershed (tributary to Pajaro) and several smaller watersheds along the Santa Barbara coast. These areas will be key areas for follow-up work by the Agricultural Cooperative Monitoring Program. Waters with the lowest risk for biostimulation occur along the relatively undisturbed Santa Cruz County coast, the Carmel River valley, the Big Sur coast, the Point Conception coast, and in higher elevation areas of most watersheds. Common to all of these low risk areas are lower population densities and less intensive land uses.

Detailed Hydrologic Unit assessment reports are available online at [http://www.waterboards.ca.gov/swamp/regionalreports.html#rb3] and [http://www.ccamp.org/ccamp/reports.html].

D. LESSONS LEARNED AND NEXT STEPS

The statewide assessments presented in this chapter represent the state's initial attempt to make broad statistical estimates of the biological condition of wadeable streams across the state. These assessments are currently based only on EMAP data and rely on benthic macroinvertebrate indices. The assessments suggest that 67-78% of the state's wadeable perennial streams are in ecologically "good" condition based on two benthic macroinvertebrate indices. These estimates can be applied to approximately 34,000 stream miles.

These results can be compared to recently released regional and national assessments. According to a U.S. EPA draft assessment report (2006), some 53% of the nation's stream miles are in "fair" to "good" condition based on a national macroinvertebrate IBI. Assessments were also made for three major regions in the country, namely, the Eastern Highlands, the Plains and Lowlands, and the West. The West was found to be in the best condition of the three, with 71% of the length of wadeable streams in "fair" to "good" condition. Based on thresholds developed for western streams (the Western EMAP IBI results), the condition California's wadeable perennial streams appears to be comparable to the condition of western streams and better than the condition of the nation's streams. This result should be interpreted with caution, however, because of differences in thresholds used. Additionally, modified channels were not sampled. These channels comprise a larger proportion of California stream length than most other western states.

Initial assessments were also made for two large regions of California. In southern coastal California, the two indices provided similar results, with both suggesting that about 60% of the wadeable perennial stream length support "fair" to "good" quality benthic conditions.

In northern coastal California, the two indices provided markedly different results. Depending on the index used, the percent of wadeable perennial stream length in "fair" to "good" condition varied from 60% to 90%. The discrepancy may potentially be due to differences in the sensitivities of the two indices or to differences in thresholds used. When the threshold for the north coast IBI was adjusted to be equivalent to the threshold used for the O/E index, the percent found to be in "good" condition decreased from 96% to 84%. We plan to re-evaluate this dataset using the revised northern coastal IBI, which is currently being refined to account for timber logging practices.

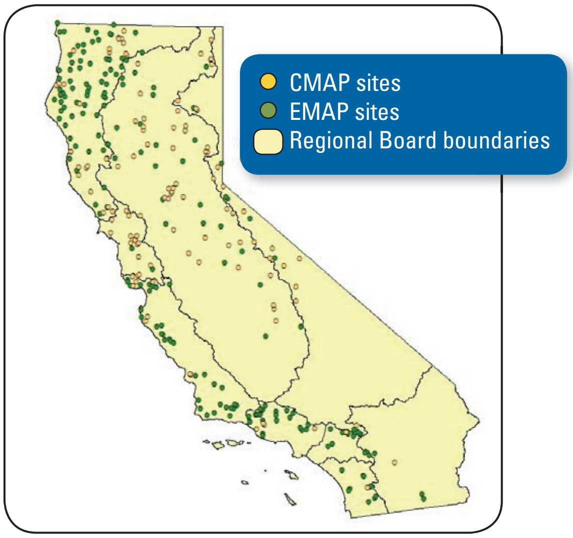


Figure 14. Sites sampled in California for the EMAP-Inland Surface Waters program from 1999-2003 and for the CMAP from 2004-2005.

These assessments for wadeable streams statewide and in the study areas use statistically established threshold values. These thresholds do not reflect water quality standards or thresholds of concern for California. We use them here for assessment purposes since statewide thresholds have not been established in California for these indicators. They should not, however, be confused for water quality standards.

Regional Water Board assessments provide more specific information on local watershed conditions for waterbodies in the Central Coast region and the Santa Clara River Watershed in the Los Angeles region. Various indicators, including benthic macroinvertebrates, toxicity, and nutrient, were used for these assessments.

Periodic statewide condition assessments will be possible through the California Monitoring and Assessment Program (CMAP). In 2004, through support from Nonpoint Source (NPS) Section 319 funds, the California Monitoring and Assessment Program (CMAP) was initiated as a collaborative effort by the Water Board's Nonpoint Souce Program and SWAMP, U.S. EPA, California Coastal Commission, and the Department of Fish and Game.

CMAP builds on the EMAP inland surface waters program and follows a similar sampling design except that it is stratified by land cover classes (such as agriculture, urban, and forest). The program will allow for periodic statewide condition assessments. It will also allow us to begin evaluating associations between observed biotic effects and nonpoint source land use categories. The historical EMAP-West data were analyzed to produce baseline condition assessments. The statewide assessments from CMAP also have the potential to produce more valid environmental protection indicators for California (EPIC)[7] that can be used to track the effectiveness of environmental protection programs over time. The program has completed the second year of a five-year monitoring study and is expected to continue through 2009 (Figure 14).

California has made significant progress in the development of bioassessment tools. The macroinvertebrate O/E index results reported in this section as well as the assessments for southern and northern coastal California were done as part of CMAP. Regional indices now exist for the northern and southern coastal areas, and additional indices are being developed for other parts of the state. A macroinvertebrate benthic IBI will soon be completed for eastern Sierra streams, and work will be continued to support the development of a key biotic condition indicator for Central Valley streams.

7. Environmental Protection Indicators for California (EPIC) were adopted by the California Environmental Protection Agency (Cal/EPA) as one meas for judging the effectiveness of the state's environmental protection programs through measurable environmental results (Cal/EPA and California Resources Agency, 2002).

Further work may also be needed to refine the relationship between bioassessments and stressors. For instance, the California Department of Fish and Game is currently being funded by the North Coast Regional Board to evaluate the responsiveness of the northern coastal macroinvertebrate IBI to timber harvest practices. Policy decisions will need to be made on how to compare results of indices based on the different assemblages, or how to interpret results in conjunction with traditional water chemistry assessments. Despite the work that still remains to be done, these tools have the potential for use at various scales including as EPIC[8] indicators, for routine and trend monitoring, and in determining the effectiveness of best management practices or restoration.

8. Ibid.

CHAPTER 4
REGIONAL BOARD SUMMARIES

This section provides a summary of the SWAMP monitoring efforts at each of the nine Regional Water Quality Control Boards. SWAMP monitoring includes statewide and regional components. Statewide efforts, conducted in partnership with existing large scale monitoring efforts, provide information on status and trends in aquatic life in streams and coastal waters. Chapters 2 and 3 of this report summarize assessments from these efforts. SWAMP is also implemented at the regional scale through locally appropriate regional monitoring programs, each following consistent methods, quality assurance, and data management to ensure comparability of results. Although activities in each region are different, most involve water and sediment chemistry, water and sediment toxicity, and biological and habitat assessments. The monitoring allows most regions to make assessments related to four beneficial uses: aquatic life protection, fish consumption, swimming (and contact recreation), and drinking water. Coastal condition assessment resulting from programs in partnership with the San Francisco Bay region and the Central Coast region are summarized in Chapter 2. Specific watershed condition assessments for the Central Coast and the Los Angeles regions are included as part of Chapter 3. Additional technical reports are available on the SWAMP Web site at [http://www.waterboards.ca.gov/swamp/regionalreports.html].

BOX 5. SWAMP BIOASSESSMENT COMMITTEE

Although the *Clean Water Act* requires maintenance of the chemical, physical, and biological integrity of the nation's waters, the Water Boards in California traditionally have focused on protecting and regulating the chemical and physical integrity of the state's waters. Biological integrity has received far less attention. With the advent and acceptance of "bioassessment" techniques in the 1990s, and the creation of the state's Surface Water Ambient Monitoring Program (SWAMP) in 2000, it is now possible for the Water Boards to take a much more active role in assessing and protecting the biological integrity of the state's waters.

SWAMP established a Bioassessment Committee in 2001 to coordinate the program's various bioassessment efforts. In 2002, SWAMP contracted with Dr. Michael Barbour to provide a peer-review of the bioassessment program. Dr. Barbour is the primary author of the U.S. EPA's bioassessment guidance for streams and rivers. The final report, The Status and Future of Bioassessment for California Streams, was issued in 2003 and is available at [http://www.waterboards.ca.gov/swamp/reports.html]. The review urged the state to consider standardization and methods consistency. The peer-review recommendations addressed methods, replication, reference condition, calibration of biological indicators, physical habitat assessment, database management, and institutional/policy issues. The Committee developed responses to each of the peer-review recommendations and issued a final memorandum that describes the process for addressing each of the recommendations.

The Committee has successfully collaborated with bioassessment practitioners throughout the state to obtain consensus for using consistent methods for bioassessment sampling. Side-by-side methods comparison studies were conducted to determine the most cost-effective method, and to develop conversion methods so historical data could be compared to the consensus method. The methods comparison manuscript has been published in the scientific literature (Herbst and Silldorff, 2006), and there is now wide agreement on a consistent method for use in wadeable streams with riffles. A similar methods comparison study is now being conducted to determine the best method for use in low-gradient streams that lack riffle habitat.

The Committee continues to work to address issues including the development of: (1) a core set of physical habitat indicators to allow for physical habitat data to be comparable across sites throughout the state; (2) standard operating procedures for reference site selection, (3) standard methods for periphyton sampling; and (4) collaborative inter-region and inter-state assessment methods.

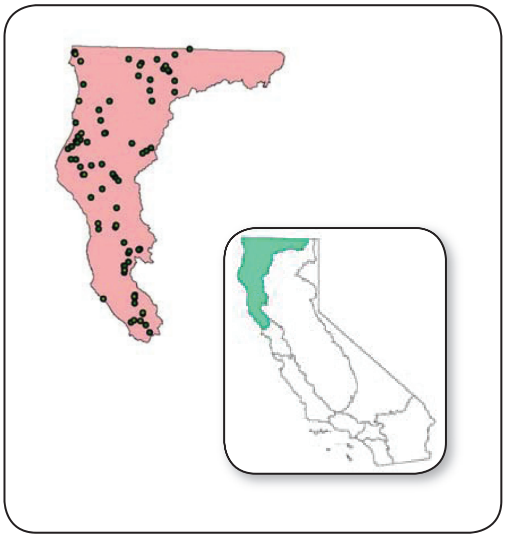


Figure 15. SWAMP monitoring stations in the North Coast Region, 2000-2005.

NORTH COAST (REGION 1) REGIONAL SURFACE WATER AMBIENT MONITORING PROGRAM

The North Coast Region is divided into two natural drainage basins, the Klamath River Basin and the North Coastal Basin. It encompasses a total area of approximately 19,390 square miles, including 340 miles of coastline and remote wilderness areas, as well as urbanized and agricultural areas. Although the North Coast Region constitutes only about 12 percent of the area of California, it produces about 40 percent of the annual runoff. Additional background information about the Region and applicable water quality standards are contained in the Water Quality Control Plan for the North Coast Basin ("Basin Plan").

The primary goal of SWAMP in the North Coast is to monitor the region's waters in a consistent manner to ensure beneficial uses are being protected. The primary objectives to achieve this goal are: (1) assess water quality related issues on a watershed basis, (2) employ a sampling design that allows the measurement and evaluation of spatial and temporal trends in water quality, and (3) use standard sampling protocols, SWAMP Quality Assurance Management Plan procedures and the SWAMP database to provide statewide consistency and availability of data. The SWAMP sites monitored in the Region from 2000 through 2005 are shown in Figure 15.

The SWAMP program in the North Coast has four primary components: surface water monitoring, indicator development for North Coast wadeable streams, indicator development of estrogenic endocrine disrupting compounds, and MTBE monitoring in drinking water reservoirs.

Since 2001, 31 long-term trend monitoring stations and 47 temporary rotating basin stations throughout the region were established. All field data and a large portion of the analytical data currently reside in the SWAMP database. The monitoring is coordinated with a number of local, state, and federal agencies. Numerous agencies and groups have used the data. Our data have been made available to the Hoopa, Karuk, and Yurok tribes of the Klamath-Trinity Basin. Regional ambient water quality data, for example, has been used by the U.S. EPA in nutrient criteria development. The first interpretative report is in preparation.

SWAMP in the North Coast has also pursued the development of two indicators. SWAMP has contributed to the development of a benthic index of biotic integrity for wadeable streams in north coastal streams. A draft report is available at [http://www.waterboards.ca.gov/swamp/reports]. The north coast index of biotic integrity is the first quantitative index that allows assessment of biological condition of streams in northern coastal California in relation to multiple anthropogenic stressors. Chapter 3 of this report summarizes the assessment results for northern coastal California based on this index (see Regional Condition Assessments).

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Also underway, as part of a collaborative effort with SWAMP in the Lower Sacramento Basin, U.S. EPA, and the University of California-Davis, is the application of an economical short-exposure bioassay method capable of detecting low concentrations of estrogenic endocrine disruptors in surface water. Estrogenic endocrine disrupting chemicals are compounds that mimic or interfere with the reproductive function of estrogen and can have variable effects on fish. The procedure involves exposing larval rainbow trout (Oncorhynchus mykiss) to water samples and analyzing their livers for vitellogenin mRNA (Vg) using SYBR Green or TaqMan® RT-qPCR (reverse-transcription quantitative polymerase chain reaction). To date, the results are encouraging. After completing a number of research and development experiments and laboratory dose response tests, the method was deployed in the field. Preliminary results indicate the ability of the method to detect these compounds in ambient surface waters. The results of several sample collections are in process. A report will be available in 2006.

Methyl tertiary butyl ether (MTBE) was monitored in drinking water reservoirs, specifically in Lake Pillsbury and Ruth Lake. MTBE is fuel derived from methanol; its discovery in groundwater supplies has led to legislation banning its use in many states. We found detectable levels of MTBE that generally followed a seasonal pattern consistent with watercraft use. All the detections were well below the State of California's Public Health Goal of 13 ppb.

SAN FRANCISCO BAY (REGION 2) REGIONAL SURFACE WATER AMBIENT MONITORING PROGRAM

The three elements of SWAMP in the San Francisco Bay Region are: (1) Water Board-led monitoring of watersheds, lakes/reservoirs, bays and estuaries other than San Francisco Bay (2) participation in the San Francisco Estuary Regional Monitoring Program,[9] and (3) coordination with watershed monitoring programs being conducted by local agencies/groups including receiving water monitoring of municipal stormwater programs and watershed groups. Water Board-led monitoring has two components: (1) monitoring fish for contaminant levels in reservoirs and coastal areas where people catch and consume fish and (2) monitoring watersheds to determine if aquatic life and recreational beneficial uses are protected. Figure 16 shows the SWAMP sites monitored in the region from 2000 through 2005.

In the five years of the program,[10] reservoirs,10 Tomales Bay, and the San Mateo County coast have been monitored to determine if fish tissue contained elevated levels of contaminants that could result in fish

9. See Chapter 2 for a summary of the assessments based on the Regional Monitoring Program for the San Francisco Bay.
10. Reservoirs included Bon Tempe, Nicasio, and Soulajule from Marin County; San Pablo and Lafayette Reservoirs in Contra Costa County; Lake Chabot, Shadow Cliffs, and Del Valle Reservoirs in Alameda County; and Stevens Creek and Anderson Reservoirs in Santa Clara County.

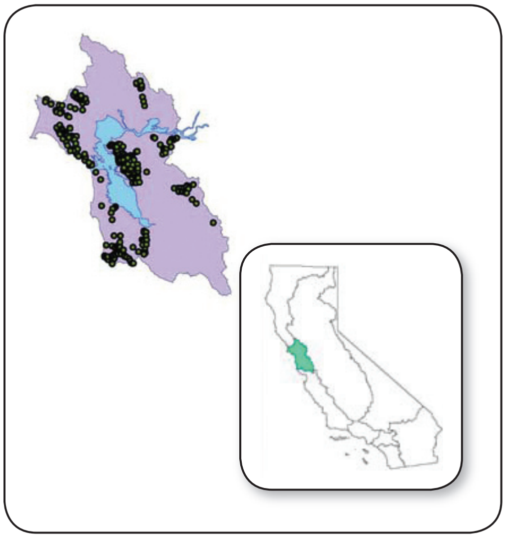

Figure 16. SWAMP monitoring stations in the San Francisco Bay Region, 2000-2005.

consumption advisories. Fish fillets were analyzed for mercury and organic contaminants, including PCBs and pesticides. All 10 of the reservoirs sampled yielded fish with edible tissue concentrations exceeding the U.S. EPA water quality criterion for mercury. In all but one of the reservoirs where fish were analyzed for PCBs, samples exceeded the state's screening value. Fish in some reservoirs contained elevated levels of chlorinated pesticides. Sufficient mercury data were available for Tomales Bay to allow the state to set consumption guidelines for eight species of fish and red rock crab. Mercury concentrations were not found at elevated concentrations in commercially grown shellfish. As such, the consumption advice does not apply to commercial oysters, clams, or mussels. On the San Mateo Coast, a few samples contained elevated mercury, but chemical concentrations were lower than in the sampled reservoirs or Tomales Bay. Concentrations of contaminants in samples of salmon were below all screening values. These results are summarized in Chemical Concentrations in Fish Tissues from Selected Reservoirs and Coastal Areas: San Francisco Bay Region, available at [http://www.waterboards.ca.gov/sanfranciscobay/].

As a result of this study, the Office of Environmental Health Hazard Assessment and county officials developed interim advisories for consuming fish in the sampled reservoirs. Signs were developed in multiple languages to post at reservoirs through a collaborative effort of state agencies, county health departments and responsible parties. The state developed a final advisory for Tomales Bay. The California Department of Health Services has included this information in their ongoing outreach and education efforts.

Seventeen watershed planning units,[11] made up of large watersheds or a series of smaller watersheds, in all of the seven hydrologic units have been monitored. Macroinvertebrate bioassessments, water column chemistry and toxicity, sediment chemistry and toxicity, nutrients and continuous monitoring of temperature, dissolved oxygen, pH, and conductivity were conducted to determine if aquatic life is protected. Trash assessments were also performed. Physical habitat assessments and extensive land use reconnaissance were conducted to determine if impacts may be related to land use activities and/or habitat alterations. Total coliform, fecal coliform and E. coli were measured during the summer in areas where water contact recreation occurs.

Water quality results from the first nine watersheds that were monitored have been evaluated. In general, water quality problems in streams appear to be more related to traditional parameters such as temperature, dissolved oxygen and coliform bacteria rather than to elevated levels of contaminants. Benthic macroinvertebrate assemblages generally reflected upstream land use. Sensitive macroinvertebrate assemblages were greatest in sites draining open space and rural residential areas, intermediate at sites draining agriculture, grazing and mixed use areas and lowest in urban areas. In many watersheds macroinvertebrate assemblages decreased in quality and richness from upstream to downstream, reflecting effects of increasing urban land use and dams.

11. The watershed planning units include: Walker, Lagunitas, Suisun, Arroyo de las Positas, Wildcat/San Pablo, San Leandro, San Gregorio, Pescadero/Butano, Stevens/Permanente, San Mateo, Petaluma, Mt. Diablo/Kirker, Berkeley/Richmond/El Cerrito creeks, Oakland creeks, Arroyo Mocho, San Francisco creeks and south Marin County coastal creeks.

In general, concentrations of contaminants and toxicity in the water column were low and toxicity was moderate. Approximately half of the sediment samples were toxic to amphipods. San Leandro Creek had the highest toxicity with 0% survival. Although some chemicals exceeded sediment quality guidelines, there appeared to be no relationship between measured chemistry and toxicity. Water samples for coliform bacteria showed that more than half of the areas evaluated exceeded the standards for water contact recreation. Continuous measurements using multiparameter probes showed that weekly average water temperatures were above benchmarks for salmonids at approximately one-third of the sites during at least one of three seasons. Approximately half of the sites had dissolved oxygen concentrations below water quality objectives. In many cases temperature and dissolved oxygen problems were related to physical habitat alterations such as lack of riparian cover. Results will be summarized in Water Quality Monitoring and Bioassessment of Nine San Francisco Bay Region Watersheds currently in draft.

A trash assessment protocol was also developed. Eighty-five trash assessment surveys were conducted at 26 sites. The surveys showed that all watersheds studied had high levels of trash, usually associated with parks, schools, or poorly kept commercial facilities near creek channels. Lower watershed sites had higher densities of trash that accumulated in the wet season from the upper watershed. Most of this trash was plastic. The study suggests that urban runoff is a major source of floatable plastic found in the ocean and on beaches. Results will be summarized in A Rapid Trash Assessment Method Applied to Waters of the San Francisco Bay Region: Trash Measurement in Streams, currently in draft.

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CENTRAL COAST (REGION 3) REGIONAL SURFACE WATER AMBIENT MONITORING PROGRAM

In the Central Coast Region, water quality assessment has been primarily achieved through monitoring activities of the Central Coast Ambient Monitoring

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Central Coast Region SWAMP reports are available at: [http://www.waterboards.ca.gov/swamp/reports.html] and [http://www.ccamp.org/ccamp/ccamp.htm].

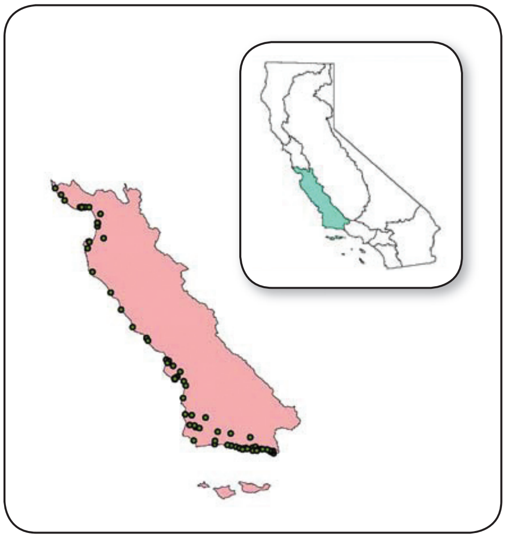

Figure 17. SWAMP monitoring stations in the Central Coast Region, 2002-2005.

Program (CCAMP). This Regional Board program has provided a screening level assessment of water quality in all Hydrologic Units (HU) of the region since 1998, with primary funding now provided by SWAMP. Monitoring activities are rotated through five watershed areas on an annual basis at 162 sites. Thirty-three additional "coastal confluence" sites are monitored continuously for trends. Figure 17 shows the SWAMP sites monitored in the region from 2000 through 2005.

Monitoring is based on a variety of chemical, physical and biological indicators, and includes monthly sampling for conventional parameters. A "weight-of-evidence" approach is utilized to evaluate beneficial use support in surface waters. Two key beneficial use questions posed in the Report to the Legislature (Report to the Legislature, Proposal for a Comprehensive Ambient Surface Water Quality Monitoring Program. State Water Resources Control Board, 2000) that established the SWAMP are addressed in this report: "Is there evidence that aquatic life is impaired?" and "Is there evidence that it is unsafe to swim?" The first question has been addressed in great part in Chapter 3, Wadeable Streams Condition, Central Coast Region. The second question is addressed below. A table is provided in Appendix A that identifies waterbodies in which criteria were exceeded for these beneficial uses at the sampling sites.

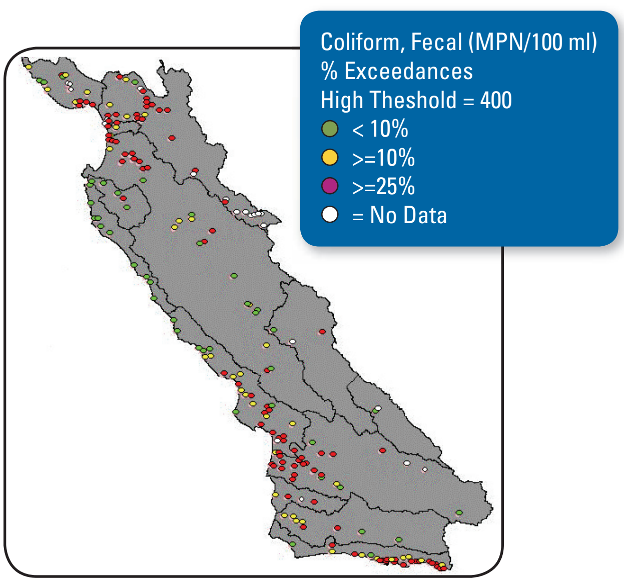

Figure 18. Percent of total samples exceeding 400 MPN/100mL for monthly samples collected at sites in the Central Coast Region.

Water Contact Recreation beneficial use is evaluated to determine impairment using monthly CCAMP data. For most locations, data are collected at long-term sites established as part of the watershed rotation approach. Monthly data includes both total and fecal coliform collected over a 15-month period. As of January 2005, E. coli data are also collected at all sites. For 303(d) listing recommendations, a binomial distribution is applied to determine percent exceedance at a given confidence level, as defined in the SWRCB 303(d) listing policy (2005). Data are evaluated using the following criteria.

- More than 10% samples exceeding 400 MPN/100 ml fecal coliform (assuming N>5)
- More than 10% samples exceeding 235 MPN/100 ml E. coli (assuming N>5)

CCAMP data has generated 24 new listings on the Section 303(d) 2002 list and 2 proposed listings on the Section 303(d) 2004 list of impaired waters. A number of waterbodies have been identified that do not support contact recreation (Figure 18). Surface water segments impaired by fecal coliform typically are found in areas dominated by urbanization, irrigated agriculture, and in some areas, rangeland. The less populated areas of Carmel Valley, Big Sur, San Simeon, Salinas valley upstream of Greenfield, the Sisquoc River, and the upper reaches of Santa Ynez River are not impaired by coliform. Land uses in these areas are typically rural residential, recreation, rangeland, or viticulture.

LOS ANGELES (REGION 4) REGIONAL SURFACE WATER AMBIENT MONITORING PROGRAM

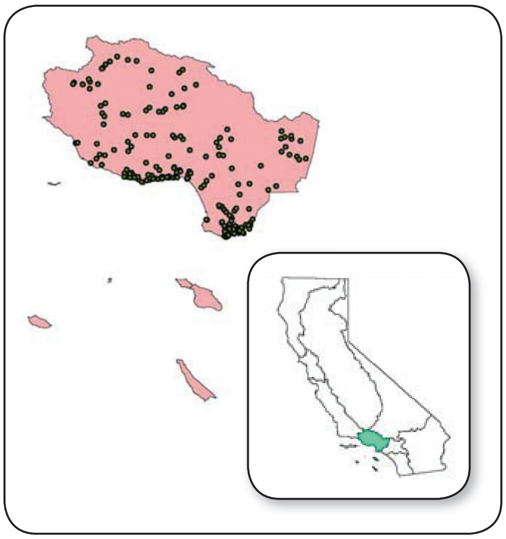

Figure 19. SWAMP monitoring stations in the Los Angeles Region, 2000-2005.

The Los Angeles Region has jurisdiction over coastal drainages between Rincon Point and the eastern Los Angeles County line, as well as the drainages of five coastal islands (Anacapa, San Nicolas, Santa Barbara, Santa Catalina, and San Clemente). The region also includes all coastal waters within three miles of the continental and island coastlines. Although the region's boundaries do not precisely follow county lines, the region includes most of Ventura and Los Angeles County, with the exception of the Lancaster-Palmdale area.

The Los Angeles Region has been divided into 10 watersheds. The goal of the Los Angeles Region's Surface Water Ambient Monitoring Program (SWAMP) is to sample each of these 10 watersheds once on a rotational basis over a five-year period. The region's SWAMP program has utilized a randomized probability based sampling design to monitor selected large watersheds (for example, Santa Clara River Watershed, San Gabriel River Watershed), while targeted sampling at designated stations has been employed for most watersheds. The SWAMP sites monitored in the region from 2000 through 2005 are shown in Figure 19.

The SWAMP monitoring has relied primarily upon a triad of indicators: bioassessment (that is, benthic macroinvertebrates in wadeable streams and benthic infauna in lakes, estuaries and coastal waters), water column toxicity, and water column chemistry (primarily conventional pollutants, such as nitrates and phosphates). At a small subset of sampling stations, trace metal and trace organic analyses, bioaccumulation sampling and sediment chemistry/sediment toxicity analyses were conducted.

SWAMP monitoring began in 2001 and 2003 with the Santa Clara River Watershed and Calleguas Creek Watershed. The results for the Santa Clara River Watershed are described above in Chapter 3 (Local Watershed Condition). A total of 13 sites were sampled once in the Calleguas Creek Watershed in 2001. No sampling was conducted in Mugu Lagoon or in the lakes located in the two watersheds as part of the SWAMP monitoring.

SWAMP monitoring of the approximately 30 coastal subwatersheds in the Santa Monica Bay Watershed began in 2003 and continued into 2004. A total of 59 sites were sampled. Sampling at all stations included field measurements, conventional water column chemistry and bacteriology. Bioassessment was conducted at 39 sites. During spring 2003, a subset of 20 stations was sampled for water column toxicity and organophosphates, and 25 stations were sampled for water column metals. Santa Monica Bay coastal waters were not included in SWAMP monitoring, but have been sampled extensively using a randomized probabilistic sampling design as part of the Southern California Bight Pilot Project in 1994, the Bight '98 Project in 1998 and the Bight '03 Project in 2003. No lakes were sampled as part of the SWAMP monitoring.

SWAMP monitoring of the Dominguez Channel Watershed occurred in 2004. A total of nine targeted stations were sampled in Dominguez Channel for bioassessment, water column toxicity, water column chemistry and microbiology. A total of five targeted stations were sampled in Machado Lake (Harbor Park Lake) for the same indicators as above, as well as sediment chemistry and sediment toxicity at all five stations and bioaccumulation monitoring (fish tissue) at three sites. A total of three targeted stations were proposed for Madrona Marsh, but sampling was unsuccessful.

SWAMP monitoring in the Los Angeles/Long Beach Harbor Watershed was conducted in 2003 utilizing a randomized probabilistic sampling design. The sampling of the harbor complex included conventional water quality, trace metals chemistry (dissolved), pesticides, PCBs, and PAH organic chemistry analysis, BTEX analysis, water column toxicity tests, and bacteriology from water samples collected at the surface from 30 random sites, and additional analyses on water samples collected at one meter "off-bottom" and water samples collected at the bottom at 10 of the 30 sites. Additionally, at these 10 intensive analyses sites, enough bottom sediment was collected to allow for enough pore water to be processed (via centrifugation at the lab) to conduct pore water organic chemistry, pore water dissolved metal chemistry, and pore water toxicity tests. Bight '03 sampling at these 10 intensive analyses sites provided benthic infaunal community, sediment chemistry, and sediment toxicity data.

SWAMP monitoring in the San Gabriel River Watershed and Los Angeles River Watershed was conducted in 2005. The San Gabriel River Watershed monitoring was conducted as a collaborative effort between SWAMP and several local stakeholder groups. A total of 30 randomized stations were sampled once during the summer 2005 for bioassessment, water column toxicity and water column chemistry (including trace metals) to provide for an overall watershed-wide assessment of water quality conditions. A total of 15 targeted sites were sampled for the same indicators to characterize conditions in areas of special interest, including the upper, middle and lower portions of the watershed and the major tributaries of the system. SWAMP monitoring also included bioaccumulation sampling (fish tissue) at three monitoring locations within the San Gabriel Watershed during 2005 (San Gabriel River Estuary, Puddingstone Reservoir and Legg Lake). SWAMP monitoring also was conducted in 2005 in Los Cerritos Channel and Wetlands (at four stations), Sims Pond (at

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Reports:

Los Angeles Region SWAMP reports are available at:
["http://www.waterboards.ca.gov/swamp/reports.html"]

one station) and Colorado Lagoon (at one station). The Los Angeles River Watershed monitoring included a total of 15 randomized stations (bioassessment, water column toxicity and conventional water column chemistry) and 7 targeted stations at the confluence points of major tributaries (adding trace metals and trace organics from the water column to the previously mentioned indicators). No lakes were sampled as part of the SWAMP monitoring.

SWAMP monitoring of the Channel Islands Watershed, Ventura River Watershed and Miscellaneous Ventura Coastal Watershed is scheduled to occur during spring/summer 2006. SWAMP monitoring is focused on the Miscellaneous Ventura Coastal Watershed and includes 4 sampling stations in Port Hueneme, 4 sampling stations in Ventura Marina/Ventura Keys and 5 sampling stations in Channel Islands Harbor/Mandalay Bay (benthic infaunal community, sediment chemistry, sediment toxicity), as well as a total of 17 sampling stations within coastal streams (bioassessment, water column toxicity, water column chemistry). No SWAMP monitoring of the Channel Islands Watershed or coastal waters of the Miscellaneous Ventura Coastal Watershed is proposed as the Bight-wide comprehensive monitoring projects conducted in 1994, 1998 and 2003, has sampled these areas. No SWAMP monitoring of the Ventura River Watershed is proposed as existing monitoring efforts adequately characterize conditions in that watershed. No lakes were sampled as part of the SWAMP monitoring.

CENTRAL VALLEY (REGION 5) REGIONAL SURFACE WATER AMBIENT MONITORING PROGRAM

The Central Valley Region is divided into four separate basins: Upper Sacramento River, Lower Sacramento River, San Joaquin River, and Tulare Lake. Additional background information about the Region and applicable water quality standards are contained in the Water Quality Control Plan for the Sacramento and San Joaquin River Basins, and Water Quality Control Plan for the Tulare Lake Basin ("Basin Plans").

The overall vision of SWAMP in this region is to provide ambient water quality assessments through a combination of long-term trend monitoring, rotational sub-regional monitoring, and special studies. The priorities of the regional effort include: coordination of internal and external monitoring efforts to leverage limited resources, evaluation of beneficial use protection and potential sources of impairment, evaluation of the effectiveness of Water Board water quality improvement policies, and the timely availability of monitoring results to the public.

The program structure is coordinated with and built around existing programs, providing the flexibility to address differing water quality issues throughout the region as well as allow creative leveraging of limited resources. With the unique characteristics, variety of existing monitoring frameworks, and diverse water quality issues faced within each basin, separate approaches toward meeting the overall SWAMP vision have emerged that can be generalized as follows: the Upper Sacramento River Basin augments monitoring efforts by local watershed groups; the Lower Sacramento River Basin coordinates broad monitoring efforts with the Sacramento River Watershed Program and includes focus on regional priority issues; the San Joaquin River Basin expands the existing framework utilized in the multi-agency Grassland Bypass Project; and the Tulare Lake Basin focuses primarily on watersheds with known water quality impairments and has increased efforts to broaden the scope throughout the basin. The SWAMP sites monitored in the Region from 2000 through 2005 are shown in Figure 20.

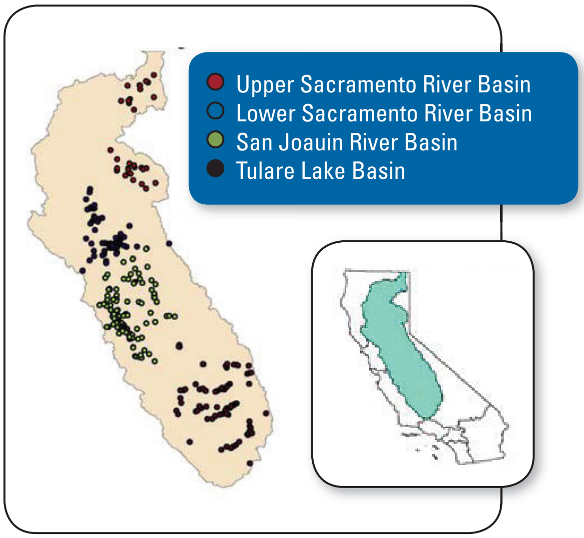

Figure 20. SWAMP monitoring stations in the Central Valley Region, 2000-2005.

Sacramento River Basin – Upper Sacramento River Basin

The upper Sacramento River Basin includes all or portions of eight counties (Modoc, Lassen, Siskiyou, Plumas, Butte, Shasta, Tehama, and Glenn), and four major rivers (Upper Sacramento, McCloud, Pit, and Upper Feather). For purposes of establishing SWAMP based monitoring programs, the area is divided into the five sub-basins:

(1) Northeastern California -Pit, McCloud and upper Sacramento Rivers.
(2) Upper Feather River -North, Middle and South Fork Feather River downstream to Lake Oroville.
(3) North Sacramento Valley-Clear, Churn, Stillwater, Cow and Bear Creeks.
(4) East Sacramento Valley (Battle, Mill, Deer, Big Chico, and Butte Creeks).
(5) West Sacramento Valley-Cottonwood, Redbank, Elder, Thomes, and Stony Creeks.

Water quality issues in this part of the region typically involve temperature, erosion and sediment discharge, nutrient loading, and bacteria concentrations. Water quality and beneficial use protection are closely linked to channel and habitat conditions. Flow depletion is also a significant factor in determining water quality condition. The area is generally rural with much public land. Past and current mining, timber harvest, agriculture, livestock grazing, and road construction practices play an important role in determining water quality and watershed condition. Urbanization and spreading housing developments are an increasing factor for water quality and habitat condition in Shasta, Tehama, Butte, and Glenn Counties.

SWAMP-funded monitoring in the upper Sacramento watershed has been underway since 2000. To date, the focus has been on two of the sub-basin areas, the upper Feather River and the Pit River watersheds. The monitoring reports for these two areas are available at: [http://www.waterboards.ca.gov/swamp/reports.html]. Expansion of SWAMP-funded monitoring into the other sub-basin areas will be explored as resources become available.

Watershed monitoring is conducted in a collaborative fashion. For example, the Department of Water Resources has provided funding for a Pit River watershed monitoring coordinator and SWAMP funded data collection and analysis. In recent years, local watershed management programs have received public grants that include funding for ambient water quality monitoring. The intent is to combine these grant projects with SWAMP resources in order to establish and implement an overall watershed monitoring program.

The approach in the upper Sacramento River basin has been to use SWAMP resources to assist in the data collection needs of locally directed watershed management programs. This data supports the development of watershed assessments, watershed management plans, community education, and provides a means to track overall success of the management program. Within each of the sub-basin areas, a Monitoring Technical Advisory Committee (TAC) is established which includes local/state/federal resource agencies, university personnel, industry representatives, and private landowners. Monitoring information collected by SWAMP and by other individuals/organizations is shared and becomes part of the overall water quality/watershed monitoring program for that sub-basin area.

Sacramento River Basin – Lower Sacramento River Basin

The lower Sacramento River sub-basins include: Westside of Sacramento Valley-Cache and Putah Watersheds, Yuba and Bear River Watersheds, American River Watershed, Lower Sacramento Valley Floor, and Sacramento Delta. SWAMP in the Lower Sacramento River Basin includes rotational monitoring and issue-specific water quality assessments, regulatory Water Board program support, grant program coordination, and final interpretive water quality assessment reports.

In a monitoring study assessing aquatic habitat conditions and benthic macroinvertebrate communities in agriculture-dominated waterways, compromised community integrity and poor aquatic habitat conditions were identified. Habitat variables including decreased riparian zone, increased channel alteration, increased sedimentation, and loss of quality benthic habitat were found to be probable determinants of macroinvertebrate community integrity. The final report is available at [http://www.waterboards.ca.gov/swamp/reports.html].

As part of a collaborative effort with the North Coast Water Board, U.S. EPA, and the University of California-Davis, SWAMP in the Lower Sacramento River Basin is involved in using bioassay procedures to screen surface waters for estrogenic endocrine disrupting chemicals. These compounds mimic or interfere with the reproductive function of estrogen and can have variable effects on fish, ranging from behavioral changes to feminization of males. Evidence is accumulating documenting the occurrence of these chemicals in surface waters across the nation. The final report for this project is expected in early 2006.

Pesticides and aquatic toxicity are high priority issues for the Central Valley Water Board. In the 1990s, the Central Valley Water Board 303(d) list of impaired water bodies was dominated by organophosphate pesticide listings for diazinon and chlorpyrifos. All major water bodies were listed, including the urban creeks. Basin Plan amendments prepared by the TMDL program and new federal regulations have resulted in urban uses of these two pesticides being virtually eliminated and agricultural uses being severely restricted. The lower Sacramento River SWAMP program collaborated with the University of California-Berkeley, the California Department of Fish and Game, and Southern Illinois University to investigate the potential impacts of urban pesticide use to resident aquatic invertebrates in Central Valley urban watersheds. It was found that the use of organophosphate pesticide replacement products, specifically pyrethroid pesticides, was linked to impairment of aquatic life uses in urban waterways. This SWAMP project is closely coordinated with a grant to the Sacramento River Watershed Program to investigate sediment toxicity and pyrethroid pesticides in agricultural and urban waterways in the Sacramento River Watershed. By leveraging limited resources and coordinating activities, the Water Board is able to better examine the magnitude of the threat posed by pyrethroid pesticides in urban and agricultural waterways. Project collaborators include local watershed groups, municipalities, Water Board regulatory programs, and the Department of Pesticide Regulation. The final manuscript of the findings is available.

The lower Sacramento River SWAMP program also has monitoring projects currently underway in the American River sub-basin, and the Feather, Yuba, and Bear River sub-basin with emphasis on aquatic toxicity, and methyl mercury and organic compounds in fish tissue, respectively.

San Joaquin River Basin

The San Joaquin River Basin covers roughly 16,000 square miles and has had a highly managed hydrology since implementation of the Central Valley Project in 1951. Most of the flow is diverted into the Friant-Kern Canal, leaving the river channel upstream of the Mendota Pool dry except during periods of wet weather flow and major snowmelt. Downstream of the Mendota Pool, flows resume from imported Delta water, eastside discharges dominated by snowmelt from the Sierra Nevada, and westside discharges dominated by agricultural drainage. The major land use along the valley floor is agriculture, with urban growth along the Interstate-5 corridor rapidly converting historical agricultural land to urban areas. Six sub-areas have been identified within this watershed: Northeast, Eastside, Southeast, Grassland, Westside, and Southern Delta Basins.

The SWAMP program in this basin builds upon a site-specific monitoring framework developed as part of the agricultural subsurface drainage management program that has evolved since 1985. The program was developed to allow expanded monitoring annually in each basin on a rotating basis. Information gathered during the rotations is added to long-term, trend monitoring stations that have been established along the river and at representative discharges from each sub-basin. Parameters were selected to measure the most limiting beneficial use impacts: salt, bacteria, total organic carbon (drinking water); temperature, toxicity, bioassessments (aquatic life); salt, boron, minerals (irrigation water supply); bacteria (recreation); and selenium (waterfowl). Bioassessment has been conducted in the through a separate effort and is coordinated with water column and sediment toxicity monitoring.

Continued coordination with local stakeholders, grant projects and other university and governmental programs is a priority for the program. Much of our SWAMP resources have been devoted to help develop a comprehensive monitoring program that works with these entities in site selection, sample coordination, data sharing, and project evaluation. Coordination of monitoring efforts between the SWAMP program, agricultural coalitions. and local stakeholders has allowed SWAMP to maximize its resources, making funds available for toxicity identification evaluations on sediment samples collected within the Westside sub-basin. Similar work with bioassessment and sediment samples was also coordinated with the Department of Pesticide Regulation at monitoring sites on Robert's Island in the Southern Delta sub-basin and Lone Tree Creek in the Eastside sub-basin.

To identify potential sources of impairment, a layered monitoring framework was developed. The first layer consists of sites selected along the mainstem of the river downstream of major inflows. The second layer is a series of sites representing inflows from specific sub-watersheds into the mainstem of the river. The final layer is a more detailed survey of water quality within each of the sub-basins-once every five years. Findings to date have included weighted evidence indicating sediment toxicity associated with pyrethroids in a number of agricultural drains, sporadic acute and chronic water column toxicity associated with organics and nutrients in the lower watershed areas, and sporadic exceedances of the single sample E. coli bacteria objective of 235 MPN, both in upper watershed area streams and the San Joaquin River itself.

Considerable resources has been directed to developing a comprehensive monitoring program, ensuring stakeholder involvement, and adopting Basin Plan Amendments and Waste Discharge Requirements in order to develop a workable and comprehensive selenium control program. The SWAMP program continues to support these efforts by maintaining the data collection, data dissemination, and program coordination of this multi-agency monitoring effort to evaluate the effectiveness of a multi-million dollar effort by the agricultural community to reduce selenium loads in the Grassland supply channels and lower San Joaquin River.

Tulare Lake Basin

The Tulare Lake Basin comprises the drainage area of the San Joaquin Valley south of the San Joaquin River, and consists of approximately 10.5 million acres, including the historical lakebed. It is essentially a closed basin, with surface water draining north to the San Joaquin River only in years with well above average rainfall. Approximately 3.5 million acres of the upper Basin are federally owned, and includes Kings Canyon and Sequoia National Parks, and substantial portions of Sierra, Sequoia, Inyo, and Los Padres National Forests. The dominant land use in the valley floor portion of the Basin is agriculture with approximately 4.5 million acres under irrigation.

Since 2001, ambient surface water quality monitoring in the Basin has in large part been funded through SWAMP. From 2001 through 2004, the overall objective of the Tulare Lake Basin SWAMP was to establish baseline conditions and characterize water quality in the waters upstream of the four major reservoirs (Pine Flat, Lake Kaweah, Success Lake, and Lake Isabella).

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Reports:
Central Valley Region SWAMP reports are available at: [http://www.waterboards.ca.gov/swamp/reports.html] and [http://www.waterboards.ca.gov/centralvalley/programs/index.html#swamp].

Information regarding the TMDL Programs and Impaired Water Bodies 303 (d) list can be found at:
[http://www.waterboards.ca.gov/centralvalley/programs/tmdl/index.html].

Information regarding the Irrigated Lands Program can be found at:
[http://www.waterboards.ca.gov/centralvalley/programs/irrigated_lands/index.html].

SWAMP also coordinates closely with outside agencies and organizations such as the U.S. Forest Service and Army Corps of Engineers who routinely monitor water quality in the reservoirs throughout the Basin. Additionally, SWAMP regularly receives requests for monitoring data and other program outreach information from other state, federal, and local agencies as well as private consulting groups and stakeholders who live and work within the Tulare Lake Basin.

For four years physical, chemical, and microbiological monitoring data was gathered quarterly from 76 monitoring sites located on the South Fork Kings, the upper reaches of the Kaweah, Tule, and Kern Rivers and associated tributaries and reservoirs in the foothill watersheds draining the west face of the Sierra Nevada. The finalized data results are now being analyzed and compiled into a report that will evaluate the data, acknowledge data gaps, identify reference and baseline water conditions, and assess the relationship of the data to the support and attainment of beneficial uses contained in the Basin Plan. Additionally, quality assurance review of the water quality data that has been collected and electronically archiving of results into SWAMP database is in progress.

With this first phase of the SWAMP program now fully underway, the focus of monitoring in the Basin is shifting to document ambient surface water quality downstream from the major reservoirs and into the historic Tulare lakebed. In June of 2005, monitoring commenced in the Tule watershed management area on the lower reach of the Tule River, Deer Creek, Porter and Bates sloughs (distributaries of the Tule River), and White River. As funding has allowed, the monitoring schedule has been monthly and has included various parameters including physical characteristics such as temperature, chemical constituents including pH, dissolved oxygen, and electrical conductivity; nutrients, specific minerals, and/or trace elements, bacteria, and water column toxicity.

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LAHONTAN (REGION 6) REGIONAL SURFACE WATER AMBIENT MONITORING PROGRAM

The Lahontan Region is the second largest Water Board region in California, spanning eastern California from the Oregon border in the north, to the Mojave Desert, San Bernardino mountains, and eastern Los Angeles County in the south. Additional background information about the Region and applicable water quality standards are contained in the Water Quality Control Plan for the Lahontan Region ("Basin Plan").

Ambient water quality monitoring at the Lahontan Region has been funded primarily by the state's Surface Water Ambient Monitoring Program (SWAMP), which was initiated in 2000. During the first five years of the SWAMP program (2000–2005), the Lahontan Region has collected water samples on a quarterly basis at about 30 streams throughout the region and is now conducting quality control checks on the data and comparing the results to relevant regulatory criteria. As soon as the quality control checks are completed, the data will be made available at the region's Web site.

Another substantial component of the region's SWAMP program is "bioassessment," which relies on surveys of instream biota (such as benthic macroinvertebrates, algae, diatoms) to assess stream health. The region has conducted bioassessment sampling at more than 80 stream sites, and is developing an index of biological integrity (IBI) for the eastern Sierra portion of the region (from the Truckee River watershed in the north, through the Owens River watershed in the south). Once completed, the IBI can be used as a yardstick to measure the health of streams in that large area.

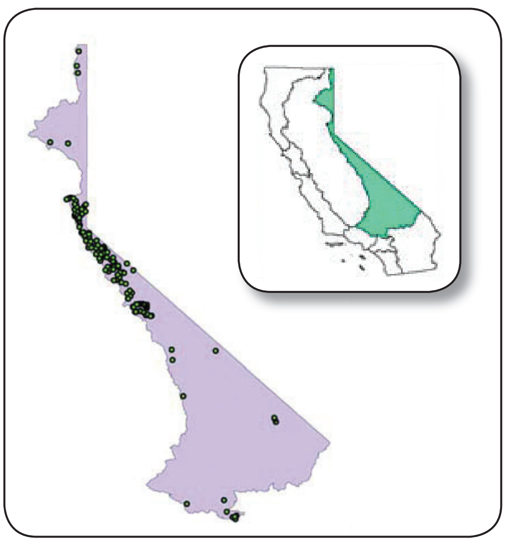

Figure 21. SWAMP monitoring stations in the Lahontan Region, 2000-2005.

The region has also conducted other surface water monitoring, including studies on turbidity at Lake Tahoe, poly-aromatic hydrocarbons (PAH) in mountain lakes (which result from boat exhaust), ecological responses to a variety of watershed restoration efforts, and a rigorous comparison of various bioassessment methods (to determine which methods are most cost-effective). Reports are currently available at the regional and state Web sites, [http://www.waterboards.ca.gov/lahontan/monitoring.html] and [http://www.waterboards.ca.gov/swamp/reports.html].

The SWAMP sites monitored in the region from 2000 through 2005 are shown in Figure 21.

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Reports:

Colorado River Basin Region SWAMP reports are available at:
[http://www.waterboards.ca.gov/swamp/reports.html].

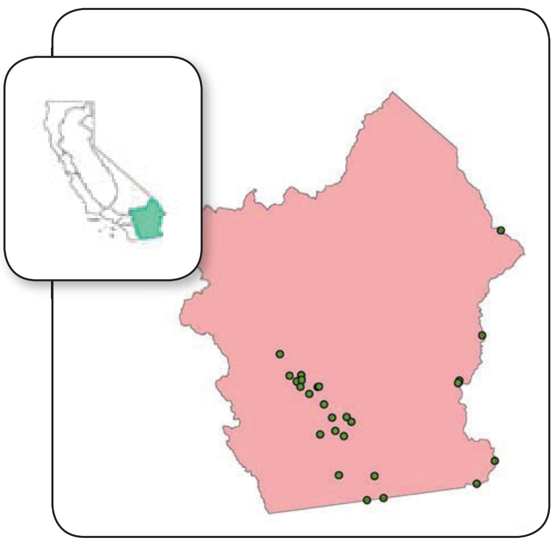

Figure 22. SWAMP monitoring stations in the Colorado River Basin Region, 2000-2005.

COLORADO RIVER BASIN (REGION 7) REGIONAL SURFACE WATER AMBIENT MONITORING PROGRAM

The Colorado River Basin Region is largely a desert area, covering approximately 20,000 square miles in the southeast corner of California. Major water bodies in the region include the Colorado River, Salton Sea, Alamo River, New River, Imperial Valley Agricultural Drains, and Whitewater River. The Lower Colorado River, the main source of surface water to the region, provides about 95% of its total supply. Water from the Colorado River is diverted via the All American Canal and the Colorado River Aqueduct for agricultural and municipal uses, draining into agricultural drains, the New and Alamo Rivers, and ultimately the Salton Sea, California's largest inland surface water. Additional background information about the region and applicable water quality standards are contained in the Water Quality Control Plan for the Colorado River Basin Region ("Basin Plan").

The state's Surface Water Ambient Monitoring Program (SWAMP) initiated in 2000 is the primary source of funding for ambient monitoring in the Colorado River Basin Region. Since its inception, ambient water and sediment samples have been collected on a semiannual basis at 13 carefully selected strategic locations along the Lower Colorado River, New River, Alamo River, Whitewater River, and Salton Sea. Water samples were analyzed for: anions and cations, organic chemistry, trace metals, bacteria indicators, and aquatic toxicity. Sediment samples were analyzed for: organic chemistry, trace metals and sediment toxicity. Physical, chemical, and biological parameters were used as water quality indicators. The data are currently being evaluated for quality control purposes, and are being assessed relative to relevant regulatory criteria. The data will be available to the public when quality control assessments are completed. The SWAMP sites monitored in the Region from 2000 through 2005 are shown in Figure 22.

Another method used by in the region to assess surface water health is "bioassessment." Bioassessment relies on surveys of instream biota to calculate an index of biological integrity (IBI). The region completed bioassessment sampling at 19 stream sites and calculated an IBI for each. These IBIs were used to assess the physical habitats of the New River, Alamo River, Whitewater River, Salt Creek, and San Felipe Creek. Future assessments will determine if conditions in these waters change over time.

The region also conducts surface water monitoring for programs other than SWAMP to evaluate sedimentation in Imperial Valley waterways; pathogens and other contaminants in the New River; and nutrients (nitrogen and phosphorus) in the tributaries of the Salton Sea. These monitoring studies support total maximum daily load (TMDL) development and implementation, and the region's Border Program. Information on these programs is available on the region's Web site, [http://www.waterboards.ca.gov/coloradoriver/].

SANTA ANA (REGION 8) REGIONAL SURFACE WATER AMBIENT MONITORING PROGRAM

The Santa Ana Region is one of the smallest of the nine Regional Boards, but with four million residents, it is one of the most densely populated. It includes two main rivers, the San Jacinto River and the Santa Ana River. Except for coastal streams that empty directly into the ocean, the stream network in the region empties directly into the Santa Ana River or the San Jacinto River. It is also a coastal region, with several miles of beaches, Newport Bay, Anaheim Bay, Huntington Harbor, and two State Water Quality Protection Areas. Additional background information about the region and applicable water quality standards are Water Quality Control Plan for the Santa Ana Region ("Basin Plan").

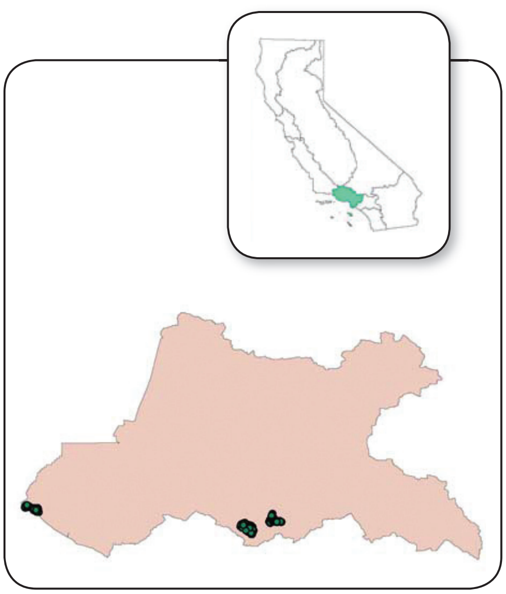

Figure 23. SWAMP monitoring stations in the Santa Ana Region, 2000-2005.

The long term vision of the SWAMP program in the Santa Ana Region is to establish a monitoring program that obtains data of acceptable quality to determine the attainment of beneficial uses in water bodies that have been classified as impaired and in water bodies for which no information is available. The monitoring questions focus on: determining the extent of lakes, harbors, and bays meeting beneficial uses and water quality objectives, determining temporal differences in water quality, determining the extent of streams meeting the wildlife beneficial use using biological indicators, and comparing data results to other similar waterbodies in the state.

Various monitoring indicators are being used including sediment chemistry, sediment and water column toxicity, benthic infauna identification, bacteria, and nutrients. Monitoring has been conducted in collaboration with volunteers from the public, city and county staff and where applicable, other regulatory agencies. The data collected will be used to provide a basis for current listings and to assist in prioritizing areas of concern and areas requiring further study. The SWAMP sites monitored in the region from 2000 through 2005 are shown in Figure 23.

Since 2000, SWAMP in the Santa Ana Region has monitored Anaheim Bay, Huntington Harbor, Lake Elsinore, and Canyon Lake. Data analysis is complete for Anaheim Bay, Huntington Harbor, and Lake Elsinore, and draft reports are underway. The data analysis for Canyon Lake is currently in progress. Assessment of data from Anaheim Bay and Huntington Harbor as part of the *Clean Water Act* Section 303(d) list of impaired waters resulted in both waterbodies being recommended for listing as impaired due to sediment toxicity. Huntington Harbor was also recommended for listing due to elevated levels of lead and chlordane in the sediment.

A stream bioassessment project is also currently underway. This is a five-year project and splits the Santa Ana Region into two main watersheds: the Santa Ana River Watershed and the San Jacinto River Watershed. The results of this project will allow us to understand and prioritize the streams in the region and identify those that are of concern and require further study.

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[http://www.waterboards.ca.gov/swamp/reports.html].

SAN DIEGO (REGION 9) REGIONAL SURFACE WATER AMBIENT MONITORING PROGRAM

The San Diego Region stretches along 85 miles of scenic coastline from Laguna Beach to the Mexican Border and extends 50 miles inland to the crest of the coastal mountain range. In a mild coastal climate, the region's growing population enjoys many water-related activities; however, little precipitation falls within this semi-arid region. Approximately 90 percent of the region's water supply is imported from Northern California and the Colorado River. Additional background information about the region and applicable water quality standards are contained in the Water Quality Control Plan for the San Diego Region ("Basin Plan").

The primary objective of the SWAMP program in the San Diego Region is the assessment of surface water quality and beneficial uses of the region's rivers, streams, reservoirs, and coastal waters. The secondary objectives

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Reports:

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[http://www.waterboards.ca.gov/swamp/reports.html].

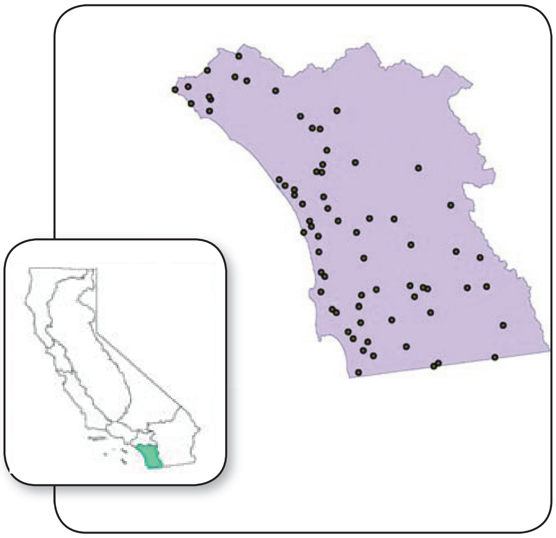

Figure 24. SWAMP monitoring stations in the Santa Diego Region, 2000-2005.

are to identify long term trends in water quality, beneficial uses and habitat, to support development and refinement of the index of biotic integrity, to develop lasting partnerships with stakeholders, and to provide public education and dissemination of information.

Between 2001 and 2004, the regional program has collaborated with the U.S. Forest Service, County of San Diego, City of San Diego, State Parks, and San Diego Stream Team to identify sample sites and collect samples in the SWAMP watersheds. The Regional Board coordinated several bioassessment monitoring projects that contributed to the development the Southern California index of biotic integrity (Ode et al., 2005). In 2004, the Regional Board coordinated post-fire sample collection with its partners to evaluate the effects of the Cedar fire on the San Diego River watershed. The Regional Board is also collaborating with the University of California-San Diego Scripps Institute of Oceanography to develop a periphyton index of biotic integrity and with researchers at San Diego State University to evaluate the condition of intermittent streams. Additionally, municipal separate stormwater systems (MS4) regulatory monitoring requirements have been coordinated with SWAMP.

The SWAMP program in the San Diego Region has completed the first rotation of 11 watersheds encompassing 49 stations sampled over 16 sampling events. Each station was sampled twice during the wet season and twice during dry season base flow conditions. Two watershed reports on the Carlsbad and Los Penasquitos hydrologic units have been completed. The SWAMP sites monitored in the region from 2000 through 2005 are shown in Figure 24.

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APPENDIX A

Table A1. Status of beneficial use support in Central Coast Regional Water Quality Control Board (Region 3) waterbodies sampled by the Central Coast Ambient Monitoring Program between 1 January 1998 and 30 June 2005.
"X" indicates exceeding the criteria, and "-" indicates the waterbody was not assessed.

HU	Waterbody	Aquatic life protection					Swimable
		Median percent oxygen saturation <85%	10% unionized ammonia > 0.025 mg/L	Survival in toxicity tests <80% of control	Biostimulatory Risk Rank > 75th quartile rank	So Cal IBI scores poor or very poor	10% Fecal Coliform Samples >400MPN/100mL
30411	Scott Creek			-			X
30411	Waddell Creek			-			
30412	Bear Creek			-			X
30412	Branciforte Creek			-		X	X
30412	San Lorenzo River			-		Near lagoon	X
30413	Aptos Creek			-			X
30413	Arana Gulch Creek			-		-	X
30413	Boulder Creek			-			
30413	Soquel Creek			-			X
30413	Valencia Creek			-			X
30413	Zayante Creek			-			X
30420	Gazos Creek			-		X	X
30510	Corralitos Creek			-			X
30510	Furlong Creek			X		-	X
30510	Harkins Slough	X		-	X	-	X
30510	Pajaro River				X	X	X
30510	Salsipuedes Creek					X	X
30510	San Juan Creek				X	X	X
30510	Struve Slough	X		-	X	-	
30510	Watsonville Slough	X			X	-	X
30520	Pescadero Creek			-			X

HU	Waterbody	DO	U_NH3	Tox	Bio stim	So Cal IBI	Coliform
30520	Uvas Creek(below res.)			-			X
30530	Carnadero Creek			-	X		X
30530	Llagas Creek(above res.)			-			X
30530	Llagas Creek(below res.)				X	X	X
30530	Tequisquita Slough	X				-	X
30540	Pacheco Creek					X	X
30550	San Benito River			-			X
30550	Tres Pinos Creek			-	X	-	X
30550	Willow Creek			-			
30600	Carneros Creek	X	X	-	X	-	X
30600	Elkhorn Slough			-		-	X
30600	Moro Cojo Slough	X	X	-	X	-	X
30700	Carmel River					X	
30700	Tularcitos Creek	X		-		-	X
30800	Big Creek			-			
30800	Big Sur River			-			
30800	Garrapata Creek			-			
30800	Limekiln Creek			-			
30800	Little Sur River			-		-	
30800	Mill Creek			-		-	
30910	Old Salinas River	X	X	-	X	-	X
30910	Salinas River (Lower)			-	X	X	X
30910	Tembladero Slough		X	-	X	-	X
30920	Alisal Creek	X	X		X	-	X
30920	Quail Creek		X	X	X	X	X
30920	Salinas Reclamation Canal	X	X	X	X	-	X
30930	Salinas River (Mid)			-			
30960	Arroyo Seco River			-			X
30970	Gabilan Creek			-		-	X
30970	San Lorenzo Creek			-		-	X
30981	Atascadero Creek(309)	X		-			X
30981	Nacimiento River(below res.)			-			
30981	Salinas River (Upper)			-			
30981	San Antonio River (below res.)			-			X
31011	San Carpoforo Creek			-			
31012	Arroyo de la Cruz	X		-			
31013	Pico Creek	X		-		-	

HU	Waterbody	DO	U_NH3	Tox	Bio stim	So Cal IBI	Coliform
31013	San Simeon Creek	X					
31014	Santa Rosa Creek					X	X
31015	Villa Creek			-		-	X
31016	Cayucos Creek			-			X
31017	Old Creek(above res.)			-			X
31018	Toro Creek	X		-		-	X
31021	Morro Creek			-		-	X
31022	Chorro Creek	X				X	X
31023	Warden Creek	X			X		X
31024	Prefumo Creek	X		-	X		X
31024	San Luis Obispo Creek					X	X
31024	Stenner Creek			-		X	X
31025	Coon Creek			-			
31026	Pismo Creek	X			X	X	X
31031	Arroyo Grande Creek(ds res.)					X	X
31031	Los Berros Creek	X		-	X		X
31100	Soda Lake	X	X	-		-	
31210	Blosser Channel		X	-	X	-	X
31210	Bradley Channel			-	X	-	X
31210	Bradley Cyn Creek	X	X	X		-	X
31210	Little Oso Flaco Creek			-	X	-	X
31210	Main Street Canal		X		X	-	X
31210	Nipomo Creek				X		X
31210	Orcutt Solomon Creek		X	X	X	X	X
31210	Oso Flaco Creek		X	X	X	-	X
31210	Oso Flaco Lake			-	X	-	X
31210	Santa Maria River			X	X	X	X
31220	LaBrea Creek			-			X
31220	Sisquoc River						
31230	Alamo Creek			-		X	X
31230	Cuyama River(above res.)			-			X
31230	Cuyama River(below res.)			-		X	X
31230	Huasna River			-		-	
31300	San Antonio Creek		X		X	X	X
31410	Salsipuedes Creek(314)			-			X
31410	San Miguelito Creek				X	-	X
31410	Santa Ynez River(below res.)				X	X	X
31451	Santa Ynez River(above res.)						

HU	Waterbody	DO	U_NH3	Tox	Bio stim	So Cal IBI	Coliform
31510	Bell Creek						X
31510	Canada de la Gaviota			X		X	X
31510	Canada del Refugio			X		X	X
31510	Dos Pueblos Canyon Creek						
31510	El Capitan Creek						X
31510	Jalama Creek			X			
31510	Los Carneros Creek				X	-	X
31510	Tecolote Creek					X	X
31531	Atascadero Creek(315)					X	X
31531	Devereux Slough	X			X	-	X
31531	Glenn Annie Creek						X
31531	Maria Ygnacio Creek		X				X
31531	San Jose Creek					-	X
31531	San Pedro Creek					-	X
31532	Arroyo Burro Creek			X		X	X
31532	Mission Creek				X	X	X
31532	Montecito Creek						X
31532	San Ysidro Creek					-	X
31533	Romero Creek					-	X
31533	Sycamore Creek					-	X
31534	Arroyo Paredon			X	X	-	X
31534	Carpinteria Creek	X		X	X	X	X
31534	Franklin Creek			X	X	-	X
31534	Rincon Creek			X		X	X
31534	Santa Monica Creek						X
31534	Toro Canyon Creek					X	X
31700	Cholame Creek	X		-	X		X
31700	Estrella River			-	X		X

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